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THE STUDY OF CHEMISTRY AT HEIDELBERG—A CORRECTION

In the April issue of THIS JOURNAL an article under the above title appeared. On page 444, in the last sentence, the following statement was made.

"Anyone who comes as Bachelor, with an Honors degree from a recognized university, is usually admitted at once, or after a few months which are occupied with practical work and end with an informal oral examination, to the "Doktorarbeit."

This should have read as follows: "Anyone coming with a Bachelor of Arts degree in chemistry from a recognized university, is admitted to the "Doktorarbeit" after some practical work and an informal oral examination."

Breath of Bacteria Becomes Plant Food. The breath of bacteria, the carbon dioxide discarded by them as a by-product of their life-processes, comes to man's table as his daily bread. We live on the exhalations of billions of tiny beings which we never see.

This, in brief paraphrase, is the revolutionary doctrine laid before the First International Congress of Soil Science by Dr. Julius Stoklasa, of the Technical Institute and Experiment Station of Prague, recognized as one of the leading authorities in the world on the difficult science of plant nutrition.

The old theory that plants build their food out of carbon dioxide which they capture from the air by means of their leaves, Dr. Stoklasa said, is entirely inadequate. The supplies of this gas in the air, according to his measurements, are not sufficient to account for the sugars, starches, and other substances formed by plants with the assistance of the sun's energy. But the soil solution contains a great deal of carbon in the form of bicarbonates, and this carbon is taken into the plant along with the other soil minerals used by the plant, and borne by the sap to the green parts where carbohydrate manufacture is going on.

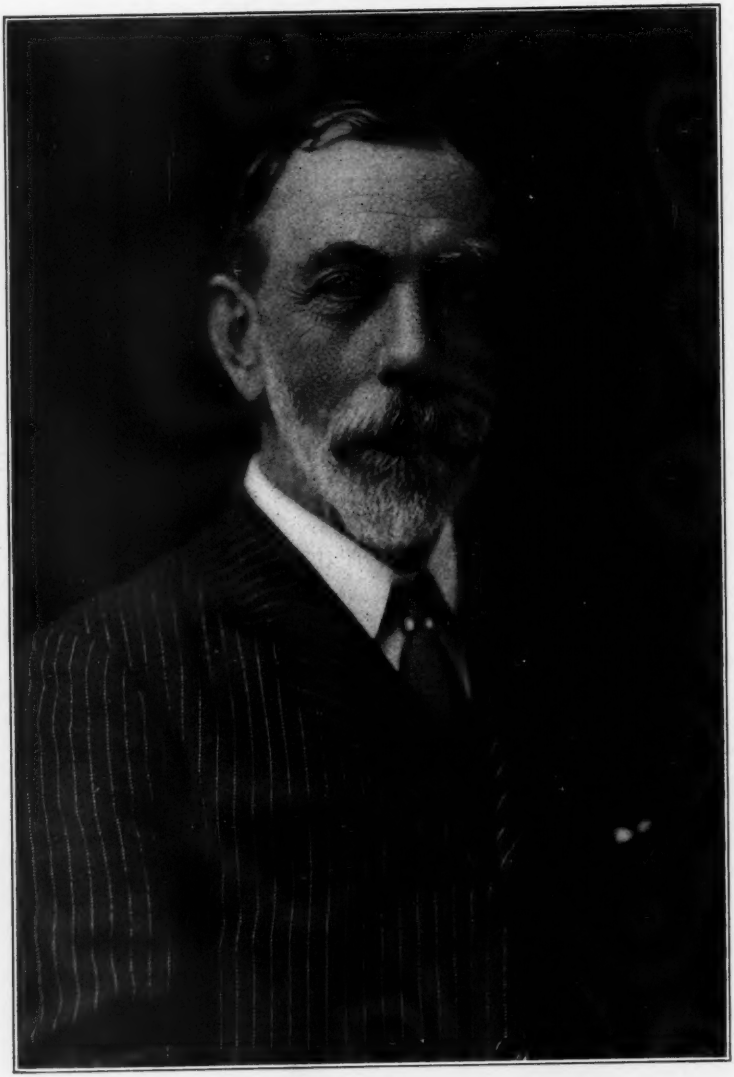
The amounts of carbon taken in from the soil, Prof. Stoklasa asserted, compare in quantity with the amounts of other minerals assimilated. Thus, for every hundred pounds of carbon so absorbed, 154 pounds of nitrogen, 113 pounds of phosphoric acid, 106 pounds of potash, 33 pounds of calcium oxide, and 26 pounds of magnesium oxide are taken in. This indicates a hitherto little suspected and wholly unmeasured part played by carbon dioxide in the soil.

Of course not nearly all of the carbon dioxide given off by soil bacteria gets into the plants. A great deal of it escapes upwards, into the air. But here the leaves are waiting for it, and it passes into the plants through the channels hitherto taught as orthodox according to the accepted doctrines of plant physiology.

Furthermore, according to Prof. Stoklasa, fertilizers added to the soil are by no means entirely for the direct benefit of the corn or clover or other crops. A large share of these plant condiments fall to the share of the bacteria, stimulating them to greater activity in the production of materials eventually used in the production of foods by the higher plants.—*Science Service*

Radio-Active Compound Speeds Bacterial Growth. The beneficial work of fixing nitrogen from the air carried on by the soil bacteria of the genus Azotobacter can be speeded up by adding compounds of the radio-active element, uranium, to the medium in which they are growing, according to Dr. Keizo Hirai of Kyushu Imperial University, Fukuoka, Japan, who spoke before the First International Congress of Soil Science in session in Washington.

Addition of compounds of a different radio-active element, thorium, did not cause any increase in the activity of the bacteria, Dr. Hirai said.—*Science Service*



Sir William Ramsay

EDITOR'S OUTLOOK

THROUGH the courtesy of Lady Ramsay, who has very kindly permitted us the use of a highly prized photograph, we are enabled to present the frontispiece which appears on the opposite page.

Sir William Ramsay

As Macauley was fond of putting it, "every schoolboy knows" of Sir William Ramsay's famous work with Lord Rayleigh in the discovery of argon and of his subsequent discoveries of helium in Cleveite and of neon, krypton, and xenon in air. Furthermore, it will be remembered that his discovery of helium as one of the decomposition products of radium furnished the first definite proof of the transmutation of chemical elements. Later he determined the density of niton from radium.

These researches endure and will continue to do so as classical examples of painstaking, accurate, experimental work. But Ramsay was not only a marvellous experimenter; he was an inspired teacher as well, and he created a famous school of physico-chemical research at University College. Many of his students are outstanding figures in the chemical world today. A few whom everyone will recognize are: Prof. S. Young, Dr. M. W. Travers, Prof. E. C. C. Baly, Prof. Whytlaw-Gray, Prof. N. T. W. Wilsmore, Prof. Irvine Masson, and Dr. F. G. Donnan.

Dr. Donnan, who has succeeded to the position of his former teacher, contributes to this issue a brief description of the laboratories at University College, which is preceded by a reminiscent note by Dr. W. A. Patrick, now of Johns Hopkins University but one time a graduate student at the University of London.

THE coming meeting of the American Chemical Society to be held at Detroit, Michigan, during the week of September 5th–10th should attract many who are able to attend only "once in a while." The comparatively central location of Detroit makes it readily accessible to large numbers and the fact that the city is the center of the automobile and allied industries constitutes an additional incentive for those who like to take advantage of the A. C. S. inspection trips to broaden their knowledge of industrial methods and developments.

Detroit Meeting

The Hotel Statler has been selected as headquarters and the registration bureau of the convention will open there at 10.00 A.M., Monday. All divisions will meet and, with the exception of the Rubber and the Paint and Varnish Divisions, will hold their sessions in the Hotel Statler and the Hotel Tuller across the street.

As usual, reduced railroad fares will be granted to members of the Society and to dependent members of their families accompanying them. In order to obtain reduced fare it is necessary to present at the ticket window an identification certificate obtained from the secretary of the Society or from the secretary of the local section to which the member belongs.

Special plans for the Division of Chemical Education include a joint session with the Section of History of Chemistry, a symposium on "The Popularization of Chemistry" and two sessions for general papers. There will be one luncheon for the division and another at which high-school teachers of chemistry will be the guests of the division. One day will be devoted to an excursion to East Lansing to inspect the new chemistry building at Michigan State College upon the invitation extended by Dr. Clarke at the Richmond meeting.

Members intending to present papers should forward titles and abstracts (preferably not over one hundred words) to Secretary Ross A. Baker, Bowne Hall, Syracuse University, Syracuse, N. Y., at once. August 5th is absolutely the final date for receipt of titles and abstracts and earlier arrival will be highly appreciated.

Tax Ruling

THE average teacher has many worries but fortunately (or unfortunately) the income tax law does not usually add to them. Nevertheless there may be an element of academic interest, at least, in a recent ruling of the United States Board of Tax Appeals on the case of Alexander Silverman, Petitioner *vs.* Commissioner of Internal Revenue, Respondent.

The proceeding arose from a determination of deficiency in income tax for the year 1921 by reason of disallowance of a deduction claimed by the petitioner as ordinary and necessary business expense for the taxable year in carrying on his duties as a professor of chemistry and a member of the faculty of the University of Pittsburgh. The findings of fact follow:

> The petitioner is a resident of Pittsburgh, Pennsylvania. He keeps his accounts on the basis of actual receipts and disbursements. Prior to and during the year 1921 he was at the head of the Department of Chemistry of the University of Pittsburgh, with the title of Professor of Chemistry, and has for the past twenty-one years been a member of the faculty of that university.
>
> As the head of the department of chemistry, it was expected of and incumbent on him as such to keep abreast in his particular field of work and in touch with other scientists in the same field, which was done among other ways by the preparation and publication of papers, by the reading of technical periodicals and by the attendance at such conventions where considerations of subjects of a scientific nature were presented and discussed.

The petitioner attended like conventions prior to 1921, did so attend in 1921 and has since so attended, such action on his part being expected and necessary, as it was of others similarly employed at the university, for the purpose of keeping thoroughly informed in his field of work and in touch with other scientists, and in order to advance the interests of the university, though his contract of employment does not specifically make mention of any such activities and there was no provision made for repayment to him of expenses so incurred.

In the taxable year mentioned, petitioner for the purposes and objects mentioned attended the American Ceramic Society at Columbus, Ohio; the American Chemical Society at Rochester, New York, and a meeting of the same society in New York City, and, in so doing, incurred and paid reasonable and actual expenses for hotel rooms, meals and railroad fare to and from said conventions, the sum of $558.75, no part of which sum has been repaid him by the university, nor by any person, society or organization, whatever. Each of the three trips mentioned occupied a week and petitioner was in attendance the full length of each convention, and for each convention prepared and delivered a paper or papers. By reason of the fact that petitioner was a member of the council of the American Chemical Society, he was in attendance prior to the general convention seasons.

The Board has held that expenditures of the character and made under the circumstances involved in this proceeding are deductible as ordinary and necessary business expense.

We note that a related ruling holds trips to political conventions and subscriptions to periodicals to be ordinary and necessary business expenses of a cartoonist. On the basis of consistency, scientific books and journals should also constitute deductible expenditures for the chemist or teacher of chemistry. Still, legal rulings and court decisions are not always consistent from the layman's point of view. Perhaps some other public-spirited chemist will complete what Dr. Silverman has begun by making test of the matter.

Repetition

WE HAVE at various times taken occasion to comment in these columns upon various factors contributory to the learning process. We have intimated, and we firmly believe, that the greatest of these is interest. But interest is not the entire sum and substance of the matter. Perhaps we are in danger of too readily taking for granted or of overlooking altogether some of the humbler and homelier influences of our own school days. Repetition was well thought of in those days and it seems to us that the continual dropping that weareth away the hardest stone is no less effective today than then.

At first thought it occurs to one that repetition and sustained interest are incompatible—that if we are to employ both we must strike an equilibrium in which one is to some extent sacrificed to the other. But this is

not necessarily true. Nor need reiteration be reduced to the sing-song drone of the Chinese school-boy which finally produces what amounts to a motor habit of the tongue, almost entirely divorced from any mental process whatsoever. The ingenuity of the good teacher will enable him to avoid both monotony and mechanical parroting.

We dimly recall an anecdote concerning a man who made the idle wager that he could dine on pheasant every day for a hundred days running. Whether he won his wager or no we do not remember but he had the right idea as to how it might be done. He employed the best chef available and gave orders that the fowl should be served to him in one hundred different ways. This was a case of making the best of a poor bargain, but versatility of presentation has at one time or another been highly esteemed for itself alone. Hebrew poetry was based almost entirely upon that principle and the best of the examples accessible to us demonstrate that it is not unpleasing.

Likewise in teaching, varied expression has other virtues besides the merely negative one of avoiding monotony. It compels the approach of a subject from different angles, thus contributing to a more comprehensive view and a more complete understanding. It encourages the appeal to different senses and so tends to fix facts and ideas more firmly than simple repetition ever could. Finally it focuses the attention of the pupil upon the significance rather than upon the form of that which we seek to convey. Too often we find that pupils are able to deal satisfactorily with a question or problem posed in one manner only to fail dismally when the same question or problem is submitted to them in a different guise.

But the clarification and fixation of ideas are not the sole benefits of repetition and variation. These expedients should also be employed to impress upon the student that he is not engaged in the acquisition of empirical information but that what we teach him today is integrally related to what he learned yesterday and the day before. Comparison, correlation, contrast—all involve repetition but they extend and amplify as well as fix. By all means let us repeat, and let us do it with a difference.

IMPRESSIONS OF THE OLD CHEMICAL LABORATORY AT UNIVERSITY COLLEGE, LONDON

W. A. PATRICK, JOHNS HOPKINS UNIVERSITY, BALTIMORE, MARYLAND

My impressions of University College must be tinged with the same unrealities as those of a doughboy's of France, for I too was observing through the mists of the great war.

During the Easter holidays of 1914, acting upon the advice of Professor Freundlich, I visited London to meet Professor Donnan of University College with a view of arranging to become his research assistant in the following academic year. I was delighted with Donnan's personality and looked forward with great eagerness to the prospect of working with such a man. The outbreak of the war chilled my hopes and I was keenly disappointed at the thought of missing the chance of spending a year in this most famous English laboratory. Donnan, however, insisted that he would "carry on" in spite of the war, so in the fall of 1914 I began the most instructive and pleasant year of my scientific life.

The old chemical laboratory in those days was the one in which Sir William Ramsay did most of his work. It was housed in one of the wings of the main college building which itself was a most imposing edifice. As usual the chemists were crowded in subways and cellars in order that their volatile fumes and gases might more easily penetrate the entire wing of the building. The laboratory consisted of a series of widely separated cold rooms (at least to a Yankee) connected by a maze of long, dark corridors. I had luxurious quarters in Donnan's office itself. I use the word luxurious because this was the only room boasting of any heating facilities. Fortunately for me, however, my work table was screened from the fireplace by a huge cabinet. This shutting off of radiant energy produced a temperature in my end of the room that compelled me to frequently migrate around the screen. This motion brought me in touch with two fires, the more important of which was Professor F. G. Donnan. During that cold, hard year I basked in the personality of this truly great chemist. A description of the man is surely unnecessary at this time, for no chemist is more widely known throughout the world than he. He studied in Germany, finally becoming van't Hoff's assistant. He has traveled extensively in Russia, South America, all western Europe, and has made many visits to this country and Canada. He is the most sociable of all chemists. At home he is constantly attending dinners, functions of all sorts, presiding at this society, and directing the affairs of that committee. When in the laboratory his time is entirely at the disposal of his students. A casual word from a student is sufficient to start his active mind. Out will come the ever-present cigarette and perhaps hours

later you will find him in the same spot eagerly following the problem of the moment.

Donnan is the most unselfish chemist that I know of at the present time. His fertile ideas are given to his students with no reservations whatsoever. In fact his first thought is the development of his students, his own scientific reputation apparently being a subject of indifference to him. This is one of the many reasons why he has to such a large degree the permanent love and well wishes of all his students.

In my day work began about 9 A.M. and continued until luncheon, which was served in the college building in a large refectory. After a solid English meal consisting of plenty of meat washed down with copious draughts of brown ale, the instructing staff repaired to the Professors' smoke room for chats around pungent cups of black coffee and still more pungent pipes of bity tobacco. When the mutual antagonisms of the above combination of drugs had sufficiently subsided, work was resumed for a few hours until tea was served. This was prepared by the laboratory "Diener" very simply by boiling together for an hour or so the proper quantities of black tea and water. Admission to the tea was in the hands of Professor Collie, and it was a rare privilege indeed to become a member of this group. Every day Donnan, Collie, Smiles, and frequently Ramsay, would gather together. In addition, guests from other departments and other universities would drop in; Baly, Lewis, Allemand, Porter, Bayliss, Bragg, etc. The talk covered the whole gamut of intellectual ideas from Ido, which was a great hobby of Donnan's, to the new Bohr atom. Donnan's knowledge of chemistry, physics, and mathematics was marvelous and one wondered how he managed to keep up with these subjects in view of his constant daily activity. Such daily gatherings represent the highest type of instruction, surpassing easily any form of lectures, textbook, or laboratory forms of imparting knowledge.

The chemical work in progress during the first year of the war was necessarily overshadowed by the great events outside the laboratories. Today chemistry at University College is housed in the large new Ramsay memorial laboratory. This is a most modern and splendidly equipped building which was entirely designed by Donnan. It is evident that University College today, possessing as it does a magnificent research chemical laboratory under the direction of Donnan, constitutes one of the important world centers of chemistry.

I do not know anything, except it be humility, so valuable in education as accuracy. Direct lies told to the world are as dust in the balance when weighed against the falsehoods of inaccuracy; and accuracy can be taught.—SIR ARTHUR HELPS

THE CHEMICAL DEPARTMENT AT UNIVERSITY COLLEGE, LONDON

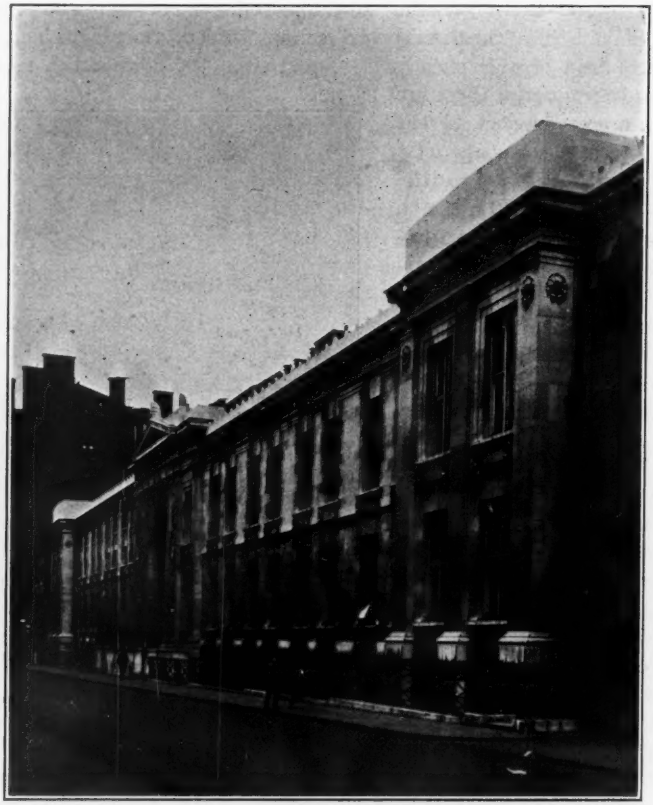
F. G. DONNAN, UNIVERSITY COLLEGE, LONDON, ENGLAND

The Chemical Department of University College, London, is housed in a relatively new building which was completed in 1915. This building consists of four floors (including an extensive basement floor) and provides accommodation for the three special sections (or departments) of inorganic, physical, and organic chemistry. Apart from the laboratories used by the undergraduates, there are many rooms devoted to the work of post-graduate students, and these provide space for about fifty research workers. The building includes also a departmental library, several lecture rooms, a metal workshop, a glass-blowing workshop, a liquid air room, and chemical and apparatus stores. The laboratory is well supplied with scientific instruments and apparatus, including, for example, those required for X-ray work, for spectroscopy in the ultra-violet and infra-red, for microscopic and ultra-microscopic work, and for the study of electrical discharges in gases. There is a special fund for the purchase of research apparatus.

F. G. DONNAN

Graduate students who are not graduates of the University of London are admitted as research workers provided they possess the necessary qualifications. If they possess a degree equivalent to the Honours B.Sc. Degree in Chemistry of the University of London, the University, if they wish it, will accept them as graduate workers for the degrees of M.Sc. or Ph.D. They may be accepted as graduate workers for the D.Sc. degree provided their standing is equivalent to that of the M.Sc. In general, this may be taken to mean that such students have already devoted a year or two to research work and have published at least one scientific paper of some merit. All candidates for the degrees of M.Sc.,

Ph.D., or D.Sc. must work two years in London. There is no general examination in chemistry in connection with these degrees. Success depends on the quality of the research work which the candidate presents and on the results of an oral test in which the candidate is examined on the subject of his thesis and relevant topics. The standard required



UNIVERSITY COLLEGE, LONDON

for the M.Sc. degree is lower than that for the Ph.D. degree. It is difficult to state precisely the difference in standard between the Ph.D. and D.Sc. degrees as at present defined by the University of London, but it may be said in broad terms that the D.Sc. degree is intended for those who have their own field of research and who can work practically in an independent manner and make a valuable contribution in this field. These remarks

concerning the degrees of the University by no means imply that research students coming to the Chemical Department of University College are expected to work for such degrees. On the contrary, students are welcomed who desire to carry out research work for its own sake and without regard to the acquirement of further university degrees.

Students desiring to carry out research work at University College, London, should apply in the first instance to Professor Collie (organic chemistry) or Professor Donnan (inorganic and physical chemistry). The fees payable to the College amount to about $100 per annum. In addition the University requires a further fee when the candidate presents his thesis for the examination.

Research workers are provided, as far as possible, free of charge, with the special apparatus required for their work. Ordinary chemical utensils may be obtained from a Loan Store on payment of a deposit, which is returned (less the value of breakages) at the conclusion of the period of work.

During recent years the research work in the laboratory has included the following topics: colloids; chemical reactions in the silent electrical discharge; spectroscopy in the ultra-violet and infra-red; X-rays and crystal structure; membrane equilibria; adsorption phenomena; ionization and infra-red emission in gaseous explosions; dielectric constants; ionization of organic compounds in liquid ammonia; physico-chemical study of long-chain organic compounds; Soret phenomenon in solutions; effects of high pressure on phase equilibria; pyrone compounds; oximes; triazole compounds; sulfur compounds in petroleum; aromatic polynitro compounds; velocity of gaseous reactions; acenaphthene; migration of alkyl groups from nitrogen into the benzene ring; orientation in the benzene ring; the physical chemistry of aqueous silicate solutions; the electro-chemical production of magnesium from fused oxide-fluoride melts; the platini-platino-chloride electrode; platino- and platini-cyanides; the physical chemistry of sericin; etc.; etc.

There are, unfortunately, no scholarships or fellowships attached to the Chemical Department.

University College possesses a gymnasium, a good athletic ground near London, and clubs for football, cricket, hockey, lawn tennis, rowing, boxing, and swimming. There are also many student societies, *e. g.*, for debating, literature, music, art, the drama, the various sciences, etc.

In general, students have to obtain lodgings in or near London, as there is only one Residential Hall attached to the College and its accommodation is very limited. There is, however, no difficulty in obtaining suitable lodgings.

In conclusion, the writer of this article would like to say that students from the United States of America will receive a hearty welcome at University College.

MILLIONTHS OF AN INCH

GUY BARTLETT, GENERAL ELECTRIC CO., SCHENECTADY, NEW YORK

Knowledge about the properties of metals has been limited in the past to observations of masses of small crystals. The usual piece of metal is a conglomeration of small, closely packed crystals, with the structure usually apparent at a glance. Zinc, for instance, is known as a brittle metal; a rod of it can be bent but slightly without snapping. Yet investigations of small, single zinc crystals show that any one crystal of the metal can be drawn out to six times its length in one direction; in another direction it is extremely brittle. The properties of zinc thus depend upon how the crystal is examined—whether "with the grain" or against it. The usual piece of zinc is really a collection of small crystals pointing in all directions, so that the properties of the metal are the combined properties of the small crystals in the different axial directions. The same holds true for other metals and other substances.

Studies of the properties of small single crystals of metals indicated that large specimens would have many unexpected properties. Single crystals of different metals have been produced by numerous experimenters and now, in the research laboratory of the General Electric Company, giant crystals have been produced and many unexpected properties discovered.

Most of the work in the General Electric laboratory has been done with copper, and in one case a crystal weighing more than 12 pounds has been produced. Somewhat resembling a projectile in appearance, it is 17 inches long and $2^1/_8$ inches in diameter. The copper crystals which have been used in the experiments have, however, been of smaller size—more nearly the size of a lead pencil. Briefly, these single crystals have been found to be 13 per cent better than ordinary (polycrystalline) copper as an electrical conductor and they can be bent as easily as a stick of soft wax. Having been bent once, however, they become ordinary copper, so that strength is required to rebend them.

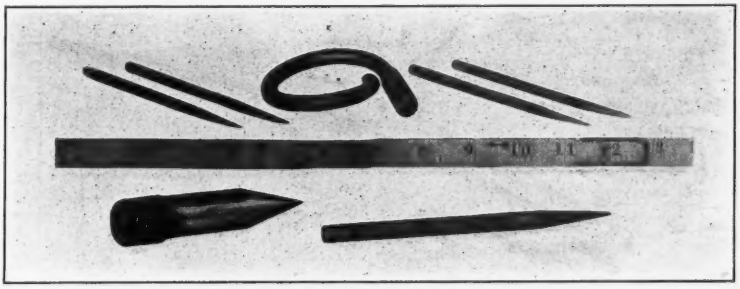
Seventy years ago Lord Kelvin found that copper wire differed much in conductivity, and urged that transatlantic cables be made of high-conductivity copper—chemically pure metal capable of transmitting current with much less loss than does the usual, more or less impure copper. Pure copper has been used almost exclusively for electrical transmission since then. Only silver, a metal much too costly for use in line wires, has a higher conductivity than pure copper.

A small increase in the conductivity of commercial copper would have great value. An increase of even 10 per cent would release for other fields an enormous tonnage of copper now used for transmitting power. The economic radius of all existing transmission systems would be increased

10 per cent, increasing by 21 per cent the area served; or the underground cable subways of cities, so many of which are taxed to capacity with their loads of today, could without enlargement carry additional loads of 10 per cent.

Calculations indicated that copper composed of a single crystal should have a conductivity 14 per cent greater than ordinary copper along one axis. Such a conductivity would be better than that of silver, so apparatus was devised for producing such crystals.

Very gradual cooling of pure copper in an electric furnace is the secret of success in producing the single crystals. The necessary amount of pure copper, in the form of a bar, is placed in a closed, cylindrical carbon crucible and slowly passed through the electric furnace. If molten metal is cooled quickly, the resultant mass is composed of very small crystals; if the melt is cooled slowly the crystals are larger. In



A COLLECTION OF SINGLE CRYSTAL COPPER

this process the melt is cooled so slowly that only one crystal is produced, and that includes the entire melt. The atoms have plenty of time in which to arrange themselves as they desire—and they prefer to build up a single crystal rather than a multitude of small ones.

In a crystal the atoms—the unit particles of the substance—are built up in regular fashion. The crystals of copper, for example, are made up of very tiny cubes, with atoms at the alternate corners of each unit cube. The large crystals grow in such a direction that the atoms are arranged in columns along the length of the crystal. It is this regular arrangement of the atoms which, it is believed, gives to the single crystals their superior conductivity when compared with ordinary copper, in which the crystals are small and the arrangement chaotic.

By means of measurements involving such quantities as 36/100,000ths of a volt and 81/1,000,000ths of an ohm, the increase in conductivity for the single crystals was determined as 13 per cent. The measurements made by two different methods, checked within $^1/_4$ of one per cent, and

were within one per cent of the calculated increase. So that no errors would be introduced because of differences in specimens, all measurements were made with the same sample. First the conductivity of the single crystal was determined; then the crystal was hammered, swaged,

THE LARGEST SINGLE CRYSTAL OF COPPER EVER MADE

and annealed so that its structure was destroyed and ordinary copper produced, and the conductivity again determined.

There is reason to believe that the conductivity of copper crystals along another axis may be even 60 per cent greater than the value for ordinary pure copper, but the growth of single crystals along this other

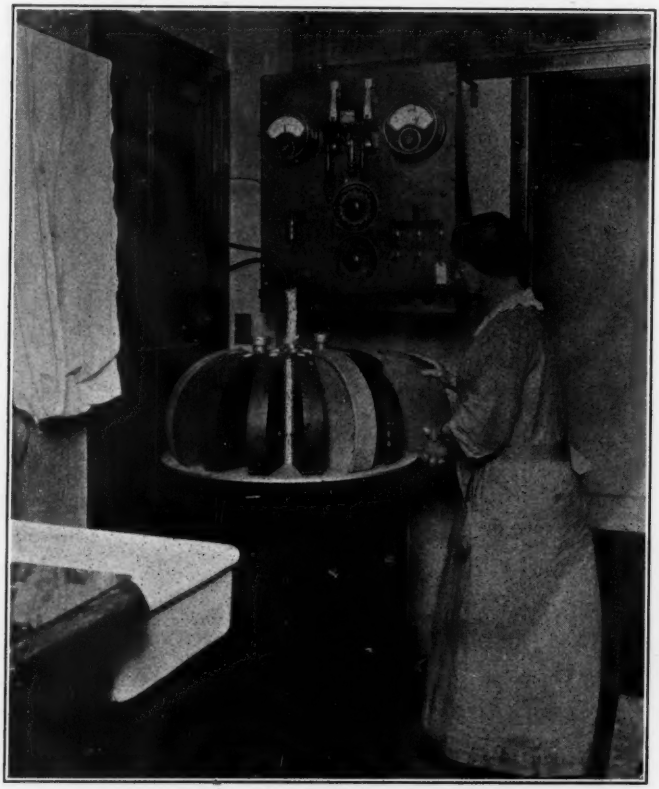
axis has not yet been brought under control. Unfortunately, there is no immediate prospect of utilizing commercially this newly discoveret high conductivity, for the single crystals are very delicate and difficuld to manufacture.

SINGLE CRYSTAL COPPER IS BENT EASILY

As said before, a piece of about the size of a lead pencil bends as easily as does a stick of soft wax if given a jerking motion; in the single crystal the atoms are arranged in equally spaced columns. When the bar is bent the spacing is changed; atoms on the outside of the bend are spread apart and those on the inside are forced together. Strains are set up and

the crystal structure is altered. The bar becomes an ordinary piece of copper, of smaller crystals facing in all directions. It is as difficult to bend as ordinary copper.

If the surface of a large single crystal of copper is nicked or dented, the structure in the neighborhood is altered. It is similarly affected by



X-RAY DIFFRACTION APPARATUS FOR STUDYING THE ARRANGEMENTS OF THE ATOMS IN THE STRUCTURE OF METALS AND OTHER SOLIDS, FOR DETERMINING COMPOSITIONS AND QUALITY

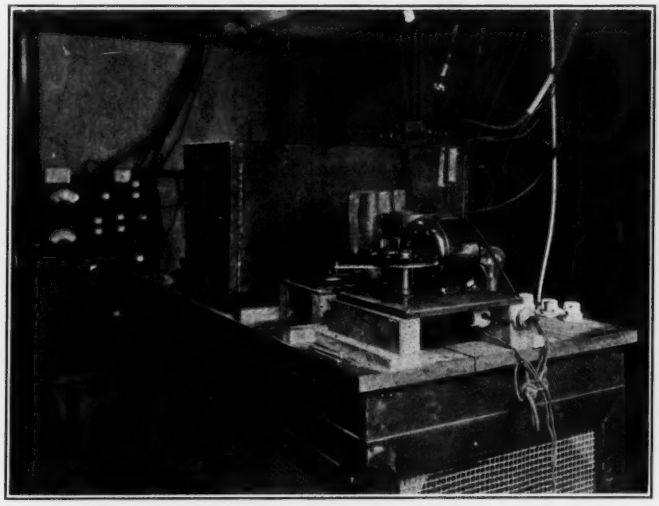
filing or polishing. When one of the rods is polished it is necessary to remove a thousandth of an inch or less at a time. Even then the structure of the new surface is altered. The condition is remedied by etching away the surface with the usual acid bath.

Externally the large single copper crystals differ little from the usual metal. X-ray analysis, however, furnishes conclusive evidence that a

single crystal has been produced. To measure directly such small distances as are encountered in dealing with spacing between atoms is, at present at least, impossible. When atoms are regularly arranged, as

SCALE OF X-RAY DIFFRACTION APPARATUS WITH AN X-RAY DIFFRACTION PATTERN

in crystals, they will bend or deflect a beam of X-rays. By measuring this deflection, atomic distances and arrangements can be determined. Two English scientists, W. H. and W. L. Bragg, first did this with small single crystals. Then Dr. A. W. Hull of the General Electric research



X-RAY APPARATUS FOR DETERMINING ORIENTATION OF SINGLE COPPER CRYSTALS

laboratory developed a method in which a powdered sample of the substance can be used.

By means of special X-ray diffraction apparatus it has been shown

that the copper rods are really single crystals. In the usual analysis a small tube of the finely powdered crystalline material is placed in the path of a narrow beam of X-rays of a specified wave-length. The substance turns the X-rays in different directions, according to the arrangement of the atoms in the minute crystals. A series of lines is thereby produced on a photographic film and these lines are used in calculations which reveal how the atoms are arranged and how far apart they are.

In studying the single crystals the method is revised so that the large crystal is used instead of the crystalline powder. The specimen is swung slowly back and forth through an angle of 30 degrees, with the edge of the crystal in the path of the X-rays. The rotation of the specimen produces the same effect as using a stationary powdered sample, as far as a stationary film is concerned. A second film, mounted on the turntable with the crystal, is also used. If the specimen is not a single crystal no

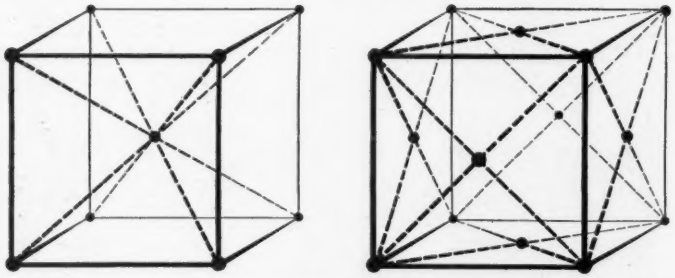


FIG. 7.—Unit crystals. Left: Body-centered cubic lattice. Right: Face-centered cubic lattice.

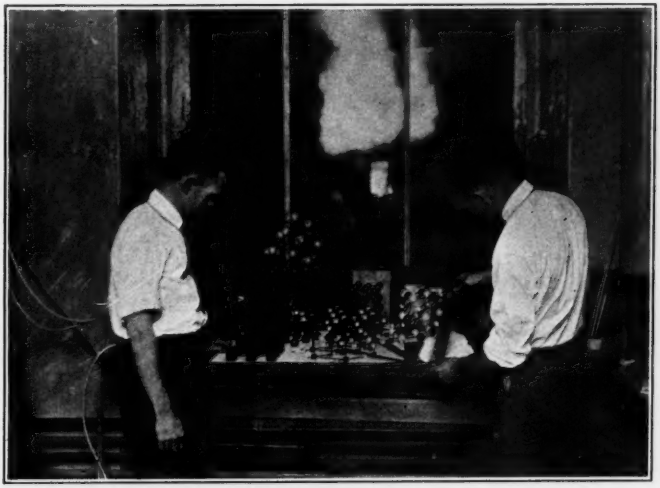
lines are obtained on the moving film since the X-rays will affect the entire film uniformly. The lines are obtained, however, and calculations based on a comparison of the two negatives show that the axis of the crystal is parallel to the direction of cooling of the copper rod.

The extreme ductility of the single crystal copper and the reference to X-ray analysis brings out the fact that, working in terms of hundredths of millionths of an inch, within an accuracy of billionths of an inch, scientists have discovered why some metals are brittle and others ductile and malleable. It depends on how the atoms of the metal are arranged. Even though the distance between the particles is a matter of hundredths of millionths of an inch, scientists have been able to determine atomic arrangements when they have called X-rays to their assistance.

Metals, crystalline substances, have their atoms arranged in orderly fashion; in liquids and such non-crystalline substances as glass the arrangement is chaotic—instead of an army there is a mob.

A piece of metal is usually composed of small crystals, irregularly arranged. It has been found that the metals which are ductile, such as copper and lead, crystallize in face-centered cubic arrangement, to use the crystallographer's term. That is, the atoms are arranged at the corners of a cube, with another atom in the center of each side of the cube. Metals which are brittle are, in general, crystals with body-centered cubic arrangement. They have atoms at each corner of a cube, but instead of another atom in each cube face they have one in the actual center of the unit cube.

When these cubes are built up thousands on top of thousands, which



X-RAY STRUCTURE SPECTRA AND ATOMIC MODELS BASED UPON THEM, SHOWING THE ATOMIC ARRANGEMENTS IN THE SOLIDS

must be done to obtain even a small particle of the substance, lines of atoms are noticed in several directions. Just as in the case of a regularly planted orchard, there are many directions in which the atoms are in parallel rows. The relative distances between these rows depend upon the geometrical design. Extending these rows into the third dimension, similarly parallel planes are produced. It is upon the arrangement of these planes that the qualities of the metal seem to depend to some extent.

When a face-centered cubic metal, such as lead or copper, is bent, the planes which contain the more closely packed atoms and which are relatively far apart slide on each other. Every atom in one of these planes is linked to three atoms in the plane above it and to three atoms in the plane below it, so that the planes tend to hold tightly to each other

while they are sliding. In the face-centered structure such planes may be found in many directions in the crystal, so that there is very little tendency for the crystal to crack—the metal is ductile or tenacious. It is easily bent without breaking, and may be hammered, drawn into wire, etc.

The reverse is generally true of body-centered structures. Here the planes which contain closely packed atoms are not held together very tightly, because every atom in one of the planes is linked to only two atoms in the plane above it and to two in the plane below it. When these planes slide on each other they tend to crack apart. Therefore, such metals cannot be worked mechanically as easily as the other type.

Such are some of the facts which have been learned with one of the three methods of X-ray chemical analysis—spectrum analysis, absorption band analysis and diffraction pattern analysis.

Small Doses of Poison Pep Up Soil Bacteria. Small amounts of chemical substances in the soil, many of them poisonous to bacteria, seem to have a stimulating effect on these microscopic organisms as well as on the bigger plants whose lives they affect, according to Dr. J. E. Greaves of the Utah Agricultural Experiment Station.

Discussing his studies on the rise and decline of soil bacteria populations before the First International Congress of Soil Sciences in Washington, Dr. Greaves stated that he has found this stimulating effect followed the use of arsenic, of sodium sulfate, and of sodium chloride, all of which are poisonous to bacteria in stronger concentrations.

The explanation which Dr. Greaves offers for this phenomenon is that the effect of the poisons is not a direct one. He inclines to the opinion that there is in the soil, along with the bacteria, a destructive substance or principle allied to the bacteriophage, prominent in recent medical research, and that the poisons cause increases or decreases in its activity, thereby causing the fluctuations in the numbers or bacteria.—*Science Service*

Lord Kelvin Honored as Scientific Pioneer. Science celebrated, June 26th, the 103rd anniversary of the birth of Lord Kelvin. He was one of the most famous scientific men the world has known.

His laboratory, an old wine cellar at Glasgow University, set the pace for scientific research.

He made the sea safe by perfecting the mariner's magnetic compass, inventing the sounding machine, blinking lighthouses, and the tide-predicting machine.

He engineered the first deep-sea cable across the Atlantic and invented the mirror galvanometer that detected the feeble electric impulses.

He laid the foundations of thermodynamics on which refrigeration and heating applications rest.

He discovered fundamental electrical principles.

He gave his support to Bell and his telephone and helped establish it.

He aided Marconi and the first wireless company.

He took out seventy patents.

He died only twenty years ago and lived to see his inventions and discoveries create revolutions and change our mode of life.—*Science Service*

THE BEGINNINGS OF LEATHER CHEMISTRY

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While color reactions between iron salts and the astringent principle of trees and galls were known to the Greeks, one may fairly start the history of leather chemistry with the Hon. Charles Howard who, about 1675, published a paper in the newly begun *Philosophical Transactions of the Royal Society* of London on "Oak Prepared for Tanning." He pointed out that any part of the oak (besides the bark), or indeed thorns or birch, could be used for tanning, and also gave instructions for the preparation of this material which foreshadowed the disintegrator.

In 1754 one Glesditsch, a German botanist, investigated a wide variety of materials—from chestnut bark to rose leaves—as sources of tanning materials. Lavoisier in 1768 also noted the tanning properties of oak leaves. Somewhat prior to this, in 1763, Dr. William Lewis attempted to analyze galls, reporting on the presence of an astringent substance, soluble in water and alcohol, which precipitated gelatin solutions and gave a black coloration with iron salts.

Among this early miscellany comes an Irishman, Dr. David Macbride, who in experimenting on a cure for sea scurvy in 1767 was led to the astonishing discovery "that lime-water extracts the virtues of oak-bark more completely than plain water." He cited testimonials from tanners but since lime precipitates tannin the only feasible explanation seems to be that his water had considerable temporary hardness. The connection between curing scurvy and tanning remains obscure.

Isolation of Tannin

These early chemists were greatly interested in the astringent principle found in all tanning materials. At that time tanning was supposed to be "simply a physical process in which the astringent property of the bark caused the hide to shrivel, harden and become non-putrescible." This astringent principle was extracted from galls and its properties studied by Ruelle, Macquer, Giannoti, and Monnet, the "four academicians of Dijon," in 1777. Scheele in 1787 also extracted the principle, obtaining a mixture of gallic acid and tannin. Dizé in 1791 confirmed Scheele's work and also obtained a resinous substance which on evaporation hydrolyzed to gallic acid. Déyeux in 1793 carried out elaborate experiments on galls and concluded that they consisted of extractive matter, a resin, a green coloring matter, gallic acid, and ligneous tissue. The first four were "in strong combination" and "to this body entire and not to any principle in particular" he ascribed the astringency necessary for tanning.

Séguin in 1797 recognized that tanning materials contained a particular water-soluble principle which combined with skin to form a compound

insoluble in water. This he regarded as essentially the same as the precipitate obtained by the action of tanning materials on the gelatin from boiled skin. To him is due credit for distinguishing clearly between tannin and gallic acid. The following year Proust introduced the name *tannin* and isolated it in an approximately pure condition by precipitating it with stannous chloride, afterwards removing the tin with sulfuretted hydrogen.

Séguin's Experiments

Armand Séguin was an interesting character living in an interesting and adventurous age. He was a personal friend of Lavoisier, which fact probably accounts for the nature of his theory of tanning. Séguin considered that the steps were: (*a*) swelling of the skin by acid, (*b*) "disoxygenation by gallic acid," (*c*) disoxygenation of the skin by the same principle, (*d*) combination of the disoxygenated skin with the true tanning matter. The "disoxygenation of the skin" apparently meant the conversion of it into a form of gelatin, which he knew gave an insoluble, imputrescible precipitate with tannin.

That Séguin was more than a theorist is proved by a "Report to the Committee of Public Safety on the new methods of tanning leather proposed by citizen Armand Séguin," written by citizens Lelièvre and Pelletier in 1797. Séguin's chief innovation was the introduction of tan liquors. Previously hides and tan were piled alternately in pits and then water poured on, or else skins were sewed into a bag and filled with tan and water. Séguin leached his tanning materials and worked his hides up through a series of liquors of increasing concentration. This process had previously been used in England—in fact, was patented by Anthony Fay in 1790, whereas Séguin's patent is 1795. But Séguin introduced two further innovations, namely deliming and plumping in 0.07% sulfuric acid prior to tanning, and in rounding the hides—removing the neck and bellies and tanning them more cheaply. His process was favorably reported on as less costly, less laborious, and decidedly more rapid. He foreshadowed a coming industry in suggesting that tanning extracts be prepared and exported to France from the forests of French Guiana and America.

Early Chemical Processes

The precaution of insisting on practical examination of a scientific process before publication was permitted had then (as perhaps it might have now) much to recommend it. In 1788 or 1789 one Saint Réal noted that boiling fresh hide extracted animal jelly whereas none was extracted on boiling leather. Hence he deduced the fact that the preliminary wet work—unhairing and swelling the skins in limes, barley infusions or old, spent, acid tan liquors—removed the animal jelly from the hides, thus

rendering them less compact, easier to swell, and capable of combining with tan more readily. Therefore he heated his hides in changes of water at 60° until no more jelly was extracted, and then tanned at 60°. Séguin's reporters investigated this and realized the folly of deducing too much from inadequate data by their further experiments which showed that jelly could be obtained by boiling at any time prior to tanning and that this jelly combined with tan.

Other and artificial sources of tanning materials were sought for even at that date. Pseiffer in 1777 claimed to tan leather by treating it with successive portions of the distillate obtained from coal and peat, mixed with water. Séguin looked into this and found that while it unhaired and swelled the skin, it did not tan. Somewhat more reliable was the work of Charles Hatchett who in 1805 announced his "discovery of artificial tannin" to the Royal Society. He digested carbonaceous material—sawdust, bitumen, turpentine, coal, a wax candle, or even a piece of skin—with nitric acid and found that the dark astringent "resin" so produced would tan leather.

Tannin Analysis

Quantitative tannin analysis dates back to the Rev. George Swayne in 1792, who precipitated tannin with "martial vitriol." He ran into a snag in that the black iron-tannin precipitate passed the filter owing to the "close attachment of the vitriolic acid" to the particles (whereby we have ink and so to destroy this combination he added "mild salt of tartar" with which the acid "has a nearer affinity." Presumably the reverend gentleman could not pass in modern freshman quantitative, since he includes in his results an experiment in which "the filter caught fire while it was drying."

George Biggin in 1799 estimated tannin by precipitating with gelatin and checked his results by hydrometer readings and by precipitation with stannous chloride. Gallic acid he determined colorimetrically by boiling a skein of worsted in a gallic acid ferric sulfate solution.

The Work of Davy

Humphry Davy, shortly after his appointment as head of the Royal Institution of London, was in 1801 granted three months leave of absence to learn sufficient about tanning to deliver lectures on "The Principles of the Art of Tanning." This proved so fascinating to his chemical mind that for some years he spent much time in trying "to elucidate this obscure but most interesting part of chemistry." His work is so comprehensive that it can only be briefly summarized here.

Of the quantitative side he discovered that the amount of the gelatin-tannin precipitate depended on the relative amounts and concentration of the reagents. Hence for analysis he used a standard isinglass solution

and a standard temperature. Gallic acid was determined colorimetrically with ferric sulfate and "extractive matter" by precipitation with aluminum chloride. He determined the amounts of the different tanning materials required to produce one pound of leather, thus ranking them by relative tanning value. He proved the adulteration of catechu extract from India. He showed that febrifuge barks (*e. g.*, cinchona) were tannin free. He estimated tannin in tea. He showed that the innermost layer of bark was richest in tannin. Liming he showed to be due to the formation of an insoluble compound between epidermis and lime. The disgusting nature of bating (with dung—a process which still partially survives) led him to try substitutes. Weak solutions of potassium and ammonium carbonates worked well on a small scale but not in a tan yard.

Tanning he regarded as a combination between hide, tannin, and extractive matter—a slow process being necessary to get pliable leather. Fifty years later Campbell Morfit of Philadelphia summed up the process, "to tan a skin is to saturate it with tannin in such a manner as to promote the slow combination of this principle with the gelatin, albumen, and fibrine contained in the former, so as to form with them a new compound. This reaction, in the operation of tanning, does not proceed spontaneously, but is the result of a slow process." This is much the same idea as Davy's, and were the modern chemical theory to be put in layman's language the above would almost be adequate.

The Chemistry of Tannin

The birth of organic chemistry led to the study of the composition of tannin. Wüttig in 1816 claimed it as an acid, Berzelius by analysis of the lead salt in 1827 gave it the formula $C_{18}H_{18}O_{12}$. He was the first to distinguish between the two classes of tannins by the color reaction with iron salts. Pelouze in 1834 introduced the etherial extraction of galls for its preparation, a method which with slight modifications is still official in the British Pharmacopoeia. Liebig the same year established the formula as $C_{18}H_{16}O_{12}$, which Pelouze, Dumas, and eventually Berzelius accepted. Pelouze noted that atmospheric oxidation of tannin gave gallic acid, while Robiquet in 1839 found the same result could be obtained anaerobically by a ferment in the galls. Larocque in 1841 discovered that alkaloids precipitated tannin and used quinine sulfate in tannin analysis. Stenhouse in 1842 subjected different tanning materials to destructive distillation and found some yielded pyrogallol while others did not. Thus he explained the blue and green colorations with iron salts and settled the much debated question whether all tannins were or were not impure varieties of a single substance. Mulder in 1847, in studying the relationship of gallic to gallotannic acid, established the latter as $C_{14}H_{10}O_9$, which formula lasted until very recent years.

Mineral Tannages

Alum tanning dates back to prehistoric times while the chrome process is too recent for mention here. Mineral tanning was, however, tried at an early date. Samuel Ashton in 1794 patented a very mixed list of mineral mixtures, including iron, copper, and zinc salts, together with ochre and sulfur. Julius Bordier in 1842 patented "such metallic saline and earthy substances" as combine with hide, rather a broad and indefinite claim. He had, however, the germ of the modern idea of mineral tannage, for he preferred the use of basic sulfate of iron.

Such is the story of leather chemistry up to 1850 and further than this we cannot now go.

Science Probes Cause of Living Light. The power of fireflies and certain kinds of insects and lower animals to become luminous at will, is thought by some biologists to be due to the action of various harmless micro-organisms that live in the animal's body. This theory has recent support from reports of the claim by Dr. Umberto Pierantoni, an Italian scientist of Naples, that ultra-microscopic organisms as well as those visible under the microscope play an important part in such reactions.

Dr. Pierantoni believes that the introduction of these ultra-microscopic organisms into the egg of an insect will cause a change in the direction of the development of the embryo leading to the formation of new organs. Investigations on luminous insects, according to the report to the scientific journal, *Nature*, have demonstrated that the presence of such micro-organisms is accompanied by the appearance of highly complicated structures such as lenses, reflectors, refractors, and analyzers of light, due to stimuli exerted by them in the cells in which they become located.

If it can be proved that these luminous ultra-microsymbionts, as they are called, actually exist, the baffling phenomenon of bioluminescence would admit of a definite explanation, scientists say.—*Science Service*

Scandinavian Coal Mines to Produce Oil. Norway and Sweden are planning to become independent of the rest of the world so far as their oil supplies are concerned. The coal mined at Kingsbay, Spitzbergen, has been found to be especially suitable for treatment by the German Bergius process for making artificial petroleum and a large plant near the mines is contemplated. A report received by the American Chemical Society also states that Sweden will use coal from the mines at Braganza Bay for oil production. The hydrogenation of coal by the process invented by Dr. Friedrich Bergius, the German chemist, produces gasoline, lubricating oil, and an artificial anthracite coal from ordinary bituminous coal.—*Science Service*

Studies Downhill Course of Elements in Soils. The decrease in the amount of mineral elements in the soil has been the object of close study by Dr. John S. Burd of the University of California, who spoke before the First International Congress of Soil Science, in session at Washington recently. He has found that these elements, some of which are essential to the growth of plants, decrease progressively in concentration as the cropping season advances, and also that in fields continuously under cultivation they show a certain decrease from year to year. This decrease, he states, is not due entirely to the bodily removal of the minerals by the plants, but that some part of them becomes bound in the soil so firmly that they cannot be pressed out or extracted with water.—*Science Service*

CANNIZZARO AND THE ATOMIC THEORY

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The principal work of Stanislao Cannizzaro, the one that earned him the admiration of his contemporaries and gave him a place of honor in the history of chemistry, is contained in the "Summary of a Course in Chemical Philosophy" published in 1858 in *Il Nuovo Cimento*." This work, together with one of another famous Italian, Count Amadeo Avogadro di Quaregna, who improved and developed Dalton's atomic conception, gave science that group of principles embodied in the atomic theory which has contributed so much to the development of modern chemistry.

The best way to bring the whole subject into view will be, therefore, to outline broadly the evolution of the atomic theory from the day of its enunciation until the appearance of Cannizzaro's work.

Dalton's hypothesis, inspired by his study of the composition of gases, created, from the day of its birth, a new goal for chemists, namely, to establish the value of the relative, if not the absolute weights of atoms, which are the basal components of the material universe, since the fundamental importance of these values for the study of chemical reactions is only too evident. And Dalton himself was the first to undertake this task. As a matter of fact, in 1808 in the "New System of Chemical Philosophy" he gave a list of atomic weights deducing them from the analysis of compounds by the aid of certain hypotheses. That is, he assumed that when two elements A and B, combine with each other, they do so according to very simple schemes, as for instance:

1 at. of A + 1 at. of B = 1 at. of C
1 at. of A + 2 at. of B = 1 at. of D
2 at. of A + 1 at. of B = 1 at. of E
1 at. of A + 3 at. of B = 1 at. of F
3 at. of A + 1 at. of B = 1 at. of G

Thus from the composition of water and ammonia he deduced the atomic weight of oxygen as seven and of nitrogen as five, assuming that of hydrogen as unity, and he confirmed these values by examining the nitrogen oxides. In fact, he found in "nitric oxide," five parts of nitrogen and seven of oxygen; in "nitric acid," five of nitrogen and fourteen of oxygen; in the "suboxide," ten of nitrogen and seven of oxygen, and he, therefore, concluded that in the first case one atom of nitrogen united with one of oxygen; in the second, one atom of nitrogen with two of oxygen; in the third, two of nitrogen with one of oxygen.

The arbitrary character of Dalton's assumptions is evident; however, the atomic hypothesis was favorably received, because it contained a general principle which allowed one to grasp from a unitary point of view

many disconnected facts, and because it permitted one at the same time to understand the new laws which were being discovered.

Nevertheless the bond between the atomic theory and the new laws was not universally recognized. Thus, while Gay-Lussac in enunciating his law (1808) brought to notice that the ratios between the combining volumes are in accordance with the atomic conception, Dalton himself denied that Gay-Lussac's experiments were in favor of the law (1810).

Wishing to interpret the chemical phenomena in the light of the doctrine of the atoms, the law of Gay-Lussac can be, in fact, explained only by admitting that equal volumes of different gases contain the same number of particles, while instead, as Dalton observed, the volumetric relations in the formation of nitrogen dioxide lead one to keep in mind that a volume of dioxide must contain half of the atoms existing in an equal volume of nitrogen and oxygen.

A different opinion was held by Berzelius, who at that period had begun his great work in continuing Richter's researches. Berzelius, wishing to explain by the atomic theory the relations which experimental facts had brought to light, accepted and appropriated the idea that equal volumes contain an equal number of atoms, but, understanding Dalton's objection, he established a clear line of separation between simple and compound gases. He admitted that equal volumes of the first named contain an equal number of atoms, but denied all meaning to the ratio between the volumes of compounds and their components.

To this he was led by the impossibility of admitting that the molecules of elements could contain more than one atom; this impossibility was a consequence of the absence of polar antagonism which, according to the dualistic theory, is necessary to produce a tendency to combine.

Berzelius assumed, however, as a dogma that all elements are monatomic and he deduced at once from Gay-Lussac's law the conclusion that in equal volumes of elementary gases the same number of atoms is contained, so that between the weights of equal volumes the same ratio exists as between the atomic weights. The ratios between the combining volumes of elements enable one for that reason to count the number of atoms that unite to form a certain compound, and therefore to establish, as he did, the formulas H_2O, N_2O_3, N_2O_5, Cl_2O_3, Cl_2O_5.

Another fundamental criterion in Berzelius' system was the use of oxygen not only as standard of atomic weights (assuming O = 100) but also of combining capacities. This criterion led him to assume that ammonia, in opposition with the ratio between the volumes of the components, has the double formula N_2H_6, which represents the amount of base which combines with a compound atom of water (containing one atom of oxygen) in order to produce oxy-salts (sulfate, etc.).

And with a view of maintaining the same equivalence to oxygen, Ber-

zelius assigned to the inorganic acids the formulas, H_2Cl_2, H_2Br_2, etc., and this not so much because he really admitted that the double atoms appearing in these acids formed an indivisible particle, as because he thought that it was impossible for an acid to contain less hydrogen than corresponds to an atom of oxygen. Thus, for analogy's sake, he wrote $H_2O.N_2O_3$; $H_2O.N_2O_5$; $H_2O.Cl_2O_3$; $H_2O.Cl_2O_5$, etc., formulas which, besides containing the famous atom of oxygen, were in accordance with the dualistic principle.

Later on, in order to show the practical indivisibility of these double atoms, he wrote them with a barred symbol: ~~H~~, ~~Cl~~, ~~N~~, etc.

But the volume law could only be applied to the gaseous elements and was not sufficient to create a system of chemistry. Other supports were needed and in seeking and choosing them Berzelius' work was truly great.

Guided by an extraordinary intuition, he followed, so to speak, an eclectic process, having recourse, according to circumstances, to those criteria which seemed to him best, and succeeded in creating a system of atomic weights which in many instances practically agrees with the modern one.

Giving always the greatest importance to the oxygen compounds, he began by assuming that in the metallic combination one atom of the metal is united with a whole number of oxygen atoms, writing, for instance, CuO, CuO_2, FeO, FeO_2, AlO_3, CrO_3 (sesqui-oxide), and CrO_6 (chromic acid) and, as in the case of iron and copper FeO_2 and CuO_2 were the stronger bases, so he wrote, for analogy's sake, KO_2, CaO_2, and likewise.

However, after the laws of Dulong and Petit and of Mitscherlich had been discovered—especially the latter with the vast network of experimental relations which Berzelius as a mineralogist could rightly appreciate—Berzelius, in order to make his atomic weights agree with them, gave up assuming that it should always be one atom of the metal which unites with a whole number of oxygen atoms and doubled without any hesitation the values for Cu, Fe, Cr, Al, and the like, writing Cu_2O, CuO, FeO, Fe_2O_3, Cr_2O_3, CrO_3, etc., and, for analogy's sake, CaO, MgO, ZnO, etc. Only for the alkaline oxides, the strongest bases, he could not bring himself to admit two atoms of metal, and so he kept on writing KO, NaO, which raised the atomic weights of potassium and sodium to 78 and 46, respectively (O = 16). Likewise for silver oxide he kept on writing AgO, thus attributing to silver, on the basis of the isomorphism between the silver and the sodium sulfates, an atomic weight of 216 instead of 108, as was required by its specific heat.

Berzelius' system appears on the whole as the work of a broad-minded chemist with a clever intuition; but it lacked a secure basis and it contained a fundamental defect—the atomic weights attributed to the alkali metals —a defect which weighed heavily, and for a long time, on the progress of chemistry.

In fact, the equivalents of acids were doubled, since they were deduced by referring them to monovalent metals, and as a consequence the formulas attributed to them were also doubled: H_2Cl_2, $H_2N_2O_6$, $C_4H_8O_4$ (acetic acid), etc. And from the double formulas of the organic acids, double formulas were deduced for the organic compounds which were derived from them.

The researches of Dumas on the vapor densities of iodine, phosphorus, sulfur, and mercury raised the doubt that even for the gaseous elements the number of chemical atoms contained in equal volumes was the same, so much so that Berzelius himself was obliged to restrict the hypothesis of the equal number of particles in equal volumes to the elementary gases which cannot be condensed—very few indeed!

On the other hand, the law of Dulong and Petit was very far from possessing general validity without exceptions; the numbers which were deduced for silver, cobalt, and tellurium were not in accordance with Berzelius' determinations and with the value required by chemical analogies and by isomorphism; and the isomorphism law, though brilliant in many typical instances, appeared artificial in others, and was apparently shaken, when Mitscherlich proved that some substances are dimorphous. As a matter of fact dimorphism seemed to prove that the shape of substances is not determined only by the number of atoms.

One understands therefore, how, owing to the frequent changes of atomic weights and their insufficient justification, a feeling of skepticism regarding the atomic conception should have spread widely; the atom became uncertain, hypothetic, and it was no wonder that the atomic theory was little by little deserted by most chemists. It gave too much the impression of an unstable edifice, built on moving ground.

The leader of Berzelius' opponents was Gmelin, who was in favor of the complete rejection of theoretical conceptions—which might be prejudices—and of the most direct return to experimental data, that is to the so-called equivalent weights that Wollaston had deduced from the study of double decompositions. These quantities of the various elements which replace each other in the double decompositions, and are, therefore, equivalent, were called by Gmelin atomic weights.

Here are a few atomic weights of Berzelius and the corresponding ones of Gmelin:

Berzelius: O = 16 ~~H~~ = 2 × 1 ~~Cl~~ = 2 × 35.5 ~~K~~ = 2 × 39 ~~Ag~~ = 2 × 108 Ca = 40 Hg = 200
Gmelin: O = 16 H = 2 Cl = 71 K = 78 Ag = 216 Ca = 40 Hg = 200

The latter, for H = 1, become O = 8, H = 1, Cl = 35.5, K = 39, Ag = 108, Ca = 20, Hg = 100. Thus, while the atomists wrote H_2O, H_2S, Cl_2O, representing by these formulas the ratios between the volumes and between the weights of the components, the supporters of equivalent atoms at-

tributed to the same compounds the formulas HO, SH, ClO which stand only for the ratios between weights.

The discovery of the polybasic acids very soon showed the insufficiency of Gmelin's system. In fact, while in the silver metaphosphate 108 parts of silver are combined with 31.4 parts of phosphorus, in the orthophosphate the same quantity of metal is united with 10.5 parts of phosphorus, and the two quantities of ortho and meta acids which contain, the one, 10.5 and the other 31.4 parts of phosphorus, are equivalent to the quantity of nitric acid containing 14 (the equivalent) of nitrogen. Which is then the equivalent of phosphorus, 31.4 or 10.5? Thus the uncertainty that Gmelin believed he had eliminated by clearing the ground away from all hypotheses reappeared, thereby obliging chemists to choose in an arbitrary way, the equivalent of a certain number of elements. On the other hand Berzelius' school, having deprived of value the vapor densities of compounds, was not able to discuss the formulas H_2Cl_2, H_2Br_2, $C_4H_8O_4$ (acetic acid) and similar ones, which as a matter of fact were only justified by the dualistic theory.

Hence chemists ended by dividing themselves into different parties, which accepted more or less the reforms that have been merely outlined here.

The greatest effort to give the formulas an harmonious meaning was made by Gerhardt who, by carefully examining a great number of organic reactions, was led to affirm that they can be represented in the simplest way when they are referred to quantities that occupy in the gaseous state equal volumes; the quantities contained in equal gaseous volumes must, therefore, be chemically comparable. Gerhardt in this way brought back the formulas of compounds to the same standard of unity, arriving chemically at that law which had been enunciated thirty years before by our fellow countryman Avogadro. Using Gmelin's atomic weights he wrote: HCl, NH_3, PCl_3 and H_2O_2, H_2S_2, S_2O_4, S_2O_6, C_2O_4, Cl_2O_2.

In the system of formulas thus deduced the atoms of carbon, oxygen, and sulfur appeared always as multiples of C_2, O_2, S_2; he deduced, therefore, the consequence that the atomic weights attributed by Gmelin to the latter were half their real value and so he doubled them, returning to Berzelius' values 12, 16, 32 and to the formulas, H_2O, H_2S, SO_2, SO_3, CO_2, Cl_2O.

The historical succession is noteworthy. Berzelius established correctly the atomic weights of oxygen, carbon, and sulfur, but was wrong, on account of the dualistic prejudice, in always using by couples the atoms of hydrogen, the halogens, and nitrogen. Gmelin, being logical as a supporter of the equivalent atomic weights, was wrong, as we atomists perceive, in uniting in a single atom with a double numerical value those indivisible couples. Gerhardt, by doubling the other atomic weights,

reëstablished the *status quo*, that is, Berzelius' system that was essentially correct.

However, Gerhardt had not a clear insight into the fundamental principles, which only could allow a complete reform. While in the case of gaseous elements he used the ratios between volumes in order to deduce the atomic weights, in the case of non-gaseous elements he let himself be guided by chemical analogy, and, believing that oxides were formed according to the same type as water, H_2O, he reduced by half the atomic weights of the metals of the alkaline earths, mercury, zinc, cadmium, iron, nickel, manganese, copper, and all the metals generally. And so in the case of mercury the chlorides became Hg_2Cl (Hg = 100, Cl = 35.5) and HgCl, corresponding the one to two and the other to one gaseous volume, contrary to the principle that he himself had affirmed, that only quantities contained in equal volumes can be chemically compared.

All these successive theories, denied by some scientists, accepted and supported partially or completely by others, ended by creating an enormous confusion, which made it very difficult, if not impossible, to compare different chemical substances, and hindered the progress of science.

For one substance, even the simplest, there existed a series of formulas. Thus for water: H_2O or HO, ~~H~~O, H_2O_2, and for methane CH_4, C_2H_4, C_2H_4. And the same formula had different meanings, according to different authors. For instance, for some H_2O_2 represented water and for others hydrogen peroxide, C_2H_4 methane or ethylene, $C_4H_4O_4$ acetic acid or fumaric and maleic acid, while Cu_2O could stand for either copper suboxide or for the oxide, and CuCl for cuprous or cupric chloride.

And yet the solution of the problem had been given since 1811 by Avogadro, who had deduced from Gay-Lussac's law of combining volumes that equal volumes contain equal numbers of molecules and that even elementary molecules are divisible.

Facing the fact that, for instance, the volume of water is double that of the oxygen which enters into its composition, one could not admit that in equal volumes of any elementary compound gas an equal number of molecules is contained and at the same time think that the molecules of elements always unite without breaking up to form the molecules of compounds. One could explain the fact either by giving up the idea of equal numbers of molecules in equal volumes, or admitting an equal number of atoms-molecules only for elements, or, finally, by giving up the idea that the molecules of elements combine integrally and admitting instead that they can break up. Dalton, as we have seen, took the first course; Berzelius, who could not admit the formation of aggregates of particles which ought to have had a charge of the same sign, followed the second. Whereas the merit of putting the question in its real light is due to Avogadro.

But the truth of the doctrines he proclaimed was not accepted by his

contemporaries who had not a sufficient preparation to understand them, and as late as 1851 Gerhardt, who, more than anyone else should have been convinced by Avogadro's principle, proclaimed that one ought not to consider it as a "molecular truth," because molecules do not all occupy the same volume.

The state of confusion and the longing for a clear explanation were set forth in the following way by Dumas in 1830; "We are yet far away from the time in which molecular chemistry will be founded on sure rules, notwithstanding the enormous advantages that this part of natural philosophy has derived from the works of Gay-Lussac, Berzelius, Dulong and Petit, Mitscherlich, and from the theoretical views of Ampère and Avogadro. The remarkable activity of Berzelius and the spirit of the chemistry with which he has enriched Germany might for the present let one hope for a near and lasting revolution in this direction."

This revolution was roused, however, only thirty years afterwards and its author was not a chemist from the north but an Italian, Stanislao Cannizzaro. It was accomplished, as a matter of fact, when Cannizzaro by publishing his "Summary" dispelled the darkness in which up to that moment all chemists had been groping.

In 1860 he expounded his views at the Congress of Karlsruhe, and Lothar Meyer relates that having received a copy of Cannizzaro's communication, immediately after having read it, he felt as if a bandage had fallen from his eyes, in such a clear way were all the difficulties removed.

Cannizzaro's "Summary" represents to this day the clearest exposition of that body of doctrines which have formed the atomic theory, until the rising of modern atomistics.

He assumes that an equal number of molecules exists in equal volumes of any kind of gas, and quite logically he deduced the divisibility of the molecules of elements. He then proves: that it is possible to deduce from the vapor densities the relative weights of molecules, even without knowing their composition, that the distinction between atom and molecule eliminates all the contradictions existing between experimental results accumulated in the preceding half century, and that the quantities by weight of an element contained in the molecular weights of all its compounds are always simple multiples of a given quantity. This smallest quantity of which all the others are simple multiples represents, therefore, the relative weight of the atom, which is thus for the first time clearly defined.

Cannizzaro established in this way the atomic weight of mercury, and showed that its value is confirmed by the specific heat law. And having proved the possibility and the way in which one must make use of the latter, he shows that the breaking up of the atomic weights of metals used by Gerhardt was just as arbitrary as the doubling of those of other elements (hydrogen, halogens, alkali metals, silver) as performed by Gmelin, since

the only guide was furnished by Avogadro's law. Thus he points out the two principal methods to establish atomic weights, the one in relationship with molecular weights, the other with the specific heat law, and he proves that the two methods lead to the same results.

In order to arrive at these conclusions, Cannizzaro was obliged to clear the ground of the apparent contradictions, which had little by little diminished the arguments in favor of the atomic theory. He divined, in fact with extraordinary acuteness, the explanation of the anomalous vapor densities due to dissociation phenomena and he was able thus to build a solid and coherent system of atomic weights to which successive research had nothing to add or change.

He himself has related how he established his system. The chaos of formulas represented an enormous difficulty for his students and, therefore, he began to try to simplify the existing doctrines in order to make them easier to be studied. This was a modest scope, worthy of a conscientious teacher, but it ended by carrying him much farther than he planned. He wished to ease the task of his pupils, and he gave chemists a lesson which had a decided effect on the future of science.

At the Karlsruhe Congress he fought a battle on two fronts. On one side he fought against the supporters of the equivalents and followers of Gmelin, whose theories—in disagreement with isomorphism, specific heat, and Avogadro's law—were even opposed to the conception of atom as a definitive quantity from an absolute point of view. On the other side he contended against the exaggerations of the unitarians and their misunderstanding of the general value of Avogadro's doctrine. One might name a third front, the old followers of Berzelius, who did not even admit Avogadro's law; but it is simpler to state that Cannizzaro threw light amidst confusion and the general contradictions.

The Karlsruhe Congress was called, in fact, by Kekulé and others in order to find if there were not some agreement between the opposing theories, and the invitation was signed, among others, by Würtz, Liebig, Wöhler, Mitscherlich, Piria, Bunsen, Erlenmeyer, Dumas, Boussingault, etc. Among the questions which were to be discussed it will be sufficient to name two: (1) "must one distinguish atoms from molecules?" and (2) "can one, by chance, omit the name of compound atom substituting with radical or residuum?"

As one can see, the fundamental questions, the principles, were still discussed.

A few years afterwards Cannizzaro's atomic weights enabled Mendelejeff to group the elements in his periodic system. The celebrated Russian chemist has left this testimony: "without those atomic weights my generalization would not have been possible." And without those atomic weights, we may add, it would not have been possible to achieve the universally

accepted system of structural formulas and all the wonderful successes that they allowed one to achieve.

Under the animating spirit of Cannizzaro's powerful mind there was revived and made to flourish that atomic conception of the structure of matter which at present dominates, without any opposition, all our natural philosophy. And the universal science remembers his name with admiration, while his grateful country has written it in her golden book among those who have honored her most.

No Sunshine Cut Out by New Glasses, Medical Tests Show. Tuberculosis victims, rickety babies, and other shut-ins can now enjoy the health-giving rays of sunlight indoors. The council on physical therapy of the American Medical Association has tried out the various glass substitutes on the market that have been designed by ingenious manufacturers to admit the ultra-violet rays cut out by ordinary window glass, and have found four that pass muster of both spectroscopic and biological tests.

Two of the samples tested are as transparent to the visible rays of sunlight as ordinary window glass though one can be supplied in an opaque form if desired. Both partake of the nature of true glasses but are more expensive. They will probably find considerable use, ultimately, in solaria, nurseries, schools, and playrooms.

The other two samples are of a less permanent character and did not rank quite so high in the tests as the first two in their power to admit anti-rachitic rays. One is composed of a wire-mesh screen filled with some sort of celluloidinous material while the other is a thin, fairly loosely woven cloth treated with a paraffin-like substance. These are opaque but more or less unbreakable and sell at a lower figure than window glass. They do not withstand weather so well as glass but are well adapted, the council suggested in their report, for windows in cow barns and chicken houses in which they can be placed in winter and removed in summer.—*Science Service*

Defends Oats against Rickets-Producing Charge. The paradoxical situation of a Scot denouncing oatmeal as a deficient article of diet and of an American defending "the halesome parritch" has arisen out of the experiments of Prof. Edward Mellanby at the University of Sheffield and of Prof. Harry Steenbock at the University of Wisconsin.

It is agreed among all physiologists that any cereal taken alone is deficient in vitamin D, which prevents the disabling bone disease, rickets, in children and young animals. Some time ago Prof. Mellanby got results with oatmeal fed to puppies that were so much worse than those that followed a diet of other grain products that he assumed the presence of an unknown substance in oats, with action opposite to that of the vitamins, which he named "toxamine."

Now Prof. Steenbock, one of the outstanding authorities on the formation and activities of vitamin D, states that he has very carefully repeated Prof. Mellanby's oatmeal experiments. He asserts that while he finds oats to be somewhat inferior to wheat in the matter of preventing rickets, he can find no evidence that they are as bad as Prof. Mellanby paints them, and that he is not convinced of the existence of the hypothetical toxamine.

While an exclusively cereal diet is practically certain to bring on an attack of rickets, Prof. Steenbock adds that as ordinarily used, with the addition of other foods of high calcium content they are valuable elements in the diet. Cereals themselves may be given an adequate vitamin D content by exposure to ultra-violet rays.—*Science Service*

THE NITROGEN PROBLEM IN AGRICULTURE*

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Just as agriculture is one of the major elements in our economic structure, so is nitrogen of major importance in land utilization and the production of plants and animals. The varying content of nitrogen in soils of different types and of different origins, the dwindling or the increase of the nitrogen resources of soils, the systems of farming employed and the methods of soil treatment all have a more or less direct relation to the quality and the quantity of the output from our agricultural lands.

The Nitrogen Capital of Soils

It is known to all well-informed persons that combined nitrogen in soils is of atmospheric origin. Soils of different types and in different localities may vary widely in their content of combined nitrogen. In very open, sandy soils there may be but 1000 pounds, or even less, of nitrogen per acre to a depth of seven or eight inches. In loam soils of fair quality we may expect to find a ton of nitrogen per acre to the same depth. Rich prairie soils may contain three tons or more of this constituent, while peat soils are much richer in nitrogen than even the best of the prairie soils.

How did these vast amounts of nitrogen accumulate in the surface soils as well as in the subsoils? What were the prominent factors in the processes of accumulation? Are there compensating factors which are to be recorded on the debit side of the ledger? In attempting to answer these questions, certain well-known phenomena should be properly evaluated. We know, in the first place, that rain, snow, and hail bring down from the atmosphere something like 3 to 10 pounds per acre annually of combined nitrogen. The average of 5 pounds per acre is usually taken as being approximately correct. We know, in the second place, that all soils contain bacteria which are able to transform elementary nitrogen into nitrogen compounds. Both anaerobic and aerobic species of such nitrogen-fixing bacteria have been studied and described. We are far from knowing definitely how much of the annual additions of combined nitrogen may be credited to these organisms. The amounts at best are not very large, even though, under exceptional conditions, the fixation of as much as 50 pounds or more per acre of atmospheric nitrogen by azotobacter may occur. Ordinarily, it is doubtful whether it would be safe to credit these organisms with an average addition under a wide range of soil and climatic conditions of more than 5 pounds of nitrogen per

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acre per annum. Still a third source of combined nitrogen in soils is the fixation of elementary nitrogen by bacteria associated with legumes. Numerous investigations on this subject in different countries have given us a fairly clear picture as to the part played by this so-called symbiotic nitrogen fixation in the nitrogen economy of soils and crops. Additions ranging from 10 pounds to as much as 200 pounds per acre, and occasionally even more, take place when legumes are grown and the entire crop plowed under. When the crop is harvested and only the stubble and roots remain in the soil, the net additions are, of course, smaller. Under ordinary circumstances we should expect net additions of at least 25 to 30 pounds per acre of nitrogen where legume crops are produced.

The facts just noted will permit us to make a rough calculation as to the amounts of nitrogen that we might expect should have accumulated in our soils since the beginning, let us say, of the Christian Era. At 5 pounds per acre annually to be credited to atmospheric precipitation and fixation by non-symbiotic bacteria, respectively, we should have an accumulation in 2000 years of 20,000 pounds or 10 tons per acre. As a matter of fact, it was already noted that a fair loam soil will contain, on the average, about one ton of combined nitrogen per acre to a depth of about 7 inches. Now, without crediting the soil nitrogen capital with contributions made by legumes and the bacteria associated with them, we find that there are obviously compensating factors which are responsible for the loss of soil nitrogen. But for such factors, our surface soils should contain very much larger amounts of nitrogen in view of the fact that additions to the nitrogen capital have been taking place through very long periods of time.

We can also draw a fairly clear picture of the changes occurring in soils that lead to losses of nitrogen. Extensive studies, in many countries, of the composition of drainage waters have established the fact that the land is losing by leaching very considerable quantities of nitrates. In humid regions, where the rainfall is 30 inches per annum or more and is fairly well distributed, losses of nitrogen equivalent to 30 to 60 pounds per acre annually are not at all uncommon. In localities where the precipitation is more abundant or where the mean annual temperatures are higher, the losses due to the leaching out of soil nitrates may be appreciably greater.

In very open, sandy soils or in arid, or semi-arid land organic matter is at times decomposed very rapidly and there is reason to think that in such rapid decomposition of organic matter elementary nitrogen may be evolved and returned to the atmosphere. In water-logged soils, nitrates may be reduced and free nitrogen evolved. Nitrogen in the form of ammonia may be lost in considerable quantities from heaps of decaying organic matter, particularly from heaps of barnyard manure. Very

considerable quantities of combined nitrogen may be carried off from surface soils in suspended particles where erosion is a factor of significance. The burning of vegetable matter on the surface of meadows, prairies, and in forests may be the cause of the escape of large quantities of nitrogen. Finally, the removal of crops and of grazing animals from the land may be the cause of nitrogen depletion.

Like the other items on the debit side of the ledger, the loss of nitrogen due to crop removal varies within wide limits. A small crop of wheat or hay, for example, may not remove in the harvested portion more than 15 pounds of nitrogen per acre. An average crop will remove substantially larger quantities. By way of example, we may note that 25 bushels of maize, including the stover, will represent a removal of about 40 pounds of nitrogen. On the basis of the average yields of non-leguminous crops, it would be safe to assume an average annual loss from the land of 30 pounds of nitrogen per acre.

When land is not disturbed (as is true of prairies, meadows, and forests) the accumulation processes are usually more prominent than those responsible for the loss of soil nitrogen. When man enters as a disturbing factor and begins to exploit the nitrogen and other plant-food resources of the soil, the factors on the debit side of the ledger may become much more prominent than those on the credit side, and a more or less rapid shrinkage in the nitrogen capital of the soil may take place.

Economics of Soil Nitrogen

The plant-food capital of the soil may be measured in more or less definite terms. If, for example, a soil of fair quality contains to the plowed depth per acre 2000 pounds of nitrogen, 500 pounds of phosphorus, and 15,000 pounds of potassium, we could ascribe to these values that are perhaps somewhat arbitrary but, nevertheless, adequate for permitting us to interpret plant-food values in the prevailing economic terms. What then is the value of 2000 pounds of soil nitrogen? Any answer that we may make is more intelligible when certain considerations are kept in mind. In the first place, nitrogen in nitrates, ammonium salts, or animal and plant residues that enter the channels of the fertilizer trade has a definite market value. At the present time, the wholesale quotations on nitrogen in ammonium sulfate, sodium nitrate, and high-grade tankage or fish are 12.5¢, 16¢, and 25¢ per pound, respectively. These are the commercial values. The agricultural values, namely, those actually reflected in crop increases brought about by applications of equivalent amounts of nitrogen in these materials, do not correspond to the commercial values, for the latter are established by conditions of demand and supply. The experimental evidence, resting on long-continued investigations in many places, shows definitely that nitrates and ammonium

salts are much more efficient than are organic nitrogen compounds in meeting the nitrogen needs of crops. It might be well to note, in the second place, that the nitrogen in soil organic matter is made up of older or more recent plant residues and that these are decomposed to an unequal extent in any given length of time. Virgin soils, when they are made arable, will give up within the first crop season perhaps 5 per cent or more of the total nitrogen in the plowed depth. The same may be said also of older cultivated soils that have been maintained in a high state of fertility by proper methods of treatment. Continued cultivation and the failure to maintain the nitrogen content of the soil encourages the relatively greater loss of the non-nitrogenous constituents of the soil organic matter and the narrowing of the carbon-nitrogen ratio. The remaining nitrogen in the soil becomes available less and less readily. All of these facts, considered in their proper relation to the present agricultural status of many land areas, would justify the statement that the nitrogen in soil organic matter is scarcely worth more than 5¢ per pound. At this rate, a soil containing one ton of nitrogen per acre to the plowed depth would have a nitrogen capital worth no more than $100. It has an exaggerated value that cannot be fully realized.

The nitrogen capital of the soil may be maintained or increased without having recourse to the use of animal manures or of commercial fertilizers. The nitrogen capital is augmented in grasslands, especially when these offer favorable conditions for the growth of clovers and of other legumes. This fact helps us to understand why farmers have gradually learned to include in their rotations such crops as timothy, red top, blue grass, clovers, and alfalfas. Grasslands are a means of conserving nitrates and ammonium compounds and, where leguminous plants are present, they are also a means of replenishing the soil nitrogen resources at the expense of atmospheric nitrogen. Leguminous green manures are another means of maintaining and increasing the nitrogen supply of our soils. While the amounts of nitrogen fixed by legumes will vary with the character of the soil, season, and the crop itself, they are always more or less substantial. It has already been noted that a leguminous crop may add nitrogen varying in amount from less than 25 to more than 200 pounds per acre per annum. Red, crimson, alsike, and other clovers, as well as sweet clover and alfalfa, are among our most efficient nitrogen-fixing plants. They will utilize for their growth such portion of the soil nitrogen as may become available to them and draw on the atmosphere for the rest. It has been ascertained by experiment that from less than 50 to as much as 90 per cent of the nitrogen present in a leguminous crop may be derived from the air. It is evident, therefore, that, by suitably arranging the succession of his crops and by using leguminous catch crops or cover crops, the farmer is able to maintain a fairly satisfactory nitrogen content

in his soil even though, for maximum economic returns, it may be desirable to supplement the natural nitrogen resources with inorganic nitrogen salts.

The use of leguminous green manures naturally raises the question as to the cost of the nitrogen obtained with the aid of these crops. If green manure nitrogen is sufficiently cheap, the farmer would naturally prefer it to nitrogen purchased in commercial fertilizers. Experimental evidence is not wanting on this point. Without any attempt at a detailed discussion, it may be noted in this place that under favorable conditions the cost of green manure nitrogen to the farmer may be as low as 2¢ per pound and as high as 15¢ per pound, or more. It is not always expedient to give up the use of the land for a part of the season in order that a green manure crop may be grown. The farmer must decide in each case how he can best obtain additions to the nitrogen capital of his soil and to what extent leguminous forage crops as a part of his regular rotation, leguminous green manures and nitrogen in commercial fertilizer may be used to the best advantage.

It might be proper also to inquire about the extent and value of the nitrogen removed in our staple crops. Conservatively estimated, we are producing something like a billion bushels of wheat, barley, and rye; a billion and a quarter bushels of oats; two and a half billion bushels of corn; 100 million tons of tame and wild hay and 12 million bales of cotton (production for 1926 was something less than 18 million bales). These, together with such crops as sorghum, Kaffir, flax, rice, potatoes, beans, peas, sweet potatoes, miscellaneous vegetables, etc., will represent an actual removal per annum of at least 5 million tons of nitrogen. But this is not the entire loss, for, as has already been noted, the losses of nitrates due to soil leaching and the losses of elementary nitrogen due to destructive oxidation of the soil organic matter, denitrification and combustion may be as large again. In a word then, the land under cultivation in the United States is losing approximately 10 million tons of nitrogen annually. The net loss is, of course, very much smaller, for the additions due to the symbiotic and non-symbiotic fixation, atmospheric precipitation, and the use of animal manures and commercial fertilizers will, in a large way, offset the loss in question. However, present-day practices in the United States are leading to very marked net losses of nitrogen, amounting to perhaps between 2 and 3 million tons annually. With an estimated loss of only 2 million tons of nitrogen, the annual shrinkage in the nitrogen capital of our soils would be equivalent to two hundred milllion dollars if we value the nitrogen lost at 5¢ per pound and to one hundred million dollars if we value it at only $2^1/_2$¢ per pound.

In selling wheat, corn, cotton, milk, beef, or pork, we dispose of a certain amount of nitrogen the value of which may be measured in more or less

definite terms. We are also able to estimate the cost of the nitrogen replacement and have, accordingly, the data needed for determining the economic aspects of our soil nitrogen problem. We are confronted by the need of making a careful study of this problem in view of the adjustments called for by changing conditions in our economic life, by changing land and labor values, and by the increasing resources and lower costs of synthetic nitrogen fertilizers.

Soil Nitrogen and the Cost of Animal and Human Food

Carbohydrates, fats, and proteins may be purchased at more or less definite prices. The latter reflect land values, interest on farm investments, labor costs, transportation costs, and crop yield levels. The types of farming in vogue, the nature of the crops grown and the relation of demand and supply are likewise important factors in determining the prevailing market prices of farm commodities. From what has already been said, it is evident that a unit of protein in wheat, corn, potatoes, cheese, or meat may have a varying market value or price, but, in the long run, such value or price must be directly affected by the extent and quality of the nitrogen capital of the soil and by replacement costs where the replacements themselves are brought about with the aid of legumes, animal manures, or of commercial fertilizers. In this connection, we should note that a bushel of wheat or a ton of alfalfa hay produced on one soil may contain less nitrogen than similar quantities of these products grown on another soil. Careful research has established the fact that by increasing the supply of available nitrogen in the soil we could, within certain limits, correspondingly increase the protein content of crops. This fact should be carefully noted when we are dealing with methods of farming that call for higher yields per acre. This fact should also have a bearing on the market value of agricultural commodities bought as a source of protein. Farmers engaged in the production of milk or of meat animals are beginning to appreciate the significance of this fact. As time goes on and as the supply of synthetic and by-product nitrogen fertilizers becomes more abundant and their cost lower, a more intelligent and determined effort will be made to obtain constantly increasing yields of protein from any given area of land. A clearer relation will be established between the protein content of any agricultural commodity and its selling price.

More Intensive Production

Where modern methods of soil treatment are employed, very large increases in yields per acre may be obtained. The agricultural history of Western Europe may well serve to illustrate this point. In countries like Denmark, Belgium, Germany, and the United Kingdom, the use of rational methods of soil treatment has resulted in very high levels of

production. In Denmark, for instance, the average yield of wheat per acre for the period 1909 to 1913 was slightly over 41 bushels. For the same period, the average yield in European Russia was 10.6 bushels and in Asiatic Russia only 9 bushels per acre. We find, similarly, very striking differences in yields for any one season. Thus, in 1921 the average yield per acre in European Russia was only 4.8 bushels and, on the other hand, in Denmark 50.7 bushels, and in the Netherlands 47.6 bushels. A number of the Western European countries produce almost consistently more than 30 bushels of wheat per acre. In this group we may include the United Kingdom, Sweden, Denmark, Belgium, the Netherlands, Switzerland, and Germany. Other European countries usually average between 15 and 20 bushels per acre. In this group, we should include Italy, France, Austria, Hungary, and several others. For any one country we may note a considerable range from season to season, as, for instance, in the case of France where the yield in 1921 was 24.3 bushels and in 1922 only 18.6 bushels per acre. Taking the entire production for a number of countries, we likewise find very impressive fluctuations from year to year. Thus, India produced in 1920 about 377 million bushels of wheat, while in the following year the production was only 250 million bushels. Argentina produced 156 million bushels in 1920 and 247 million bushels in 1923. Even more striking is the difference in the wheat yields of Canada when the years 1923 and 1924 are compared. In the former year the total production was 474 million bushels, whereas in 1924 it was only 271 million bushels.

There is a wide fluctuation in the production of wheat in the United States when the individual states are considered. Thus, for the period 1914 to 1920 the average production per acre was only 10 bushels in North Carolina and 26.4 bushels in Arizona. On the whole, the tendency in the United States is toward larger production per acre, even though the decline in yields in a portion of the wheat-growing territory offsets the increase per acre in the older agricultural areas. A comparison of the average yields for the period 1909 to 1913 and of 1914 to 1920 shows that the average for the former was 14.7 bushels per acre and for the last-named period 14.6 bushels per acre. A study of the yields in individual states during these periods shows that in the far western states there have been marked declines in yields during the last decade. For instance, in Idaho the average yield per acre for the period 1909 to 1913 was 27.5 bushels, whereas for the period 1914 to 1920 it was 22.9 bushels. As against that, we find that the average yields for these periods in New York State were 20 and 21.8 bushels and in Ohio 14.8 and 18.0 bushels per acre, respectively.

In developing our own agricultural policies, we might well take to heart the experience of some of the European countries in their efforts to intensify production. An interesting discussion of this matter from

the English point of view may be found in "The Land and the Nation," which represents a report submitted in behalf of The Liberal Land Committee for the period 1923 to 1925. Among other matters, reference is made in this report to the increased production in some of the Western European countries and the part played by education in bringing about such increases. We are told (page 132), "In other countries the increase in average yields has been very great. (In Germany, from 10.1 cwt. to 17.7 ; in Belgium, 12.0 to 20.7; in Holland, 13.4 to 20.7; in Denmark, 16.0 to 23.8.) In none of these countries has the process of selecting only the best land for cereals gone anything like so far as in England. Their increased productivity per acre is due to definite farming advance. So, too, in branches of farming other than cereals. It has already been pointed out that Great Britain, between 1873 and 1922, showed a decline in stock units per 100 acres of crops and grass from 34.3 to 33.1, whereas Holland, for example, in a comparable period, has increased her stock units from 32.7 to 44.9; Belgium, from 31.1 to 47.0; Germany, from 25.7 to 30.8; and Denmark, 24.0 to 39.4.

"How has this been done in other countries?

"In reply, Sir Thomas Middleton's well-known pamphlet on the Recent Development of German Agriculture may be cited.

" 'The average German farmer,' he says, 'uses nitrogenous manures nearly twice as liberally as the average British farmer and employs about one-third more phosphates and five times more potash.' "

We may note, further, another statement of Middleton's to the effect that "The chief factor in developing the use of artificial manures in Germany, however, was unquestionably a well-organized system of technical education. Investigation at the research stations established the precise uses of these manures; trustworthy advice was supplied by institutions, by peripatetic instructors, by technical leaflets and by agricultural newspapers; and the farmer, even the backward *Bauer*, like other Germans, brought his methods into line with authority."

It may be of interest to quote here Tables B, C, and E from "The Land and the Nation," for these tables are very explicit in showing how more intensive methods of soil treatment have led to increased yields per acre and a striking increase in the carrying capacity of grasslands.

Tables B and C represent a comparison of the production of cereals and live stock in Great Britain and in Denmark, while Table E contains information as to the number of live stock carried per 100 acres of crops and grasslands in the countries named at different periods. Lengthy comment is, of course, unnecessary. It will suffice at this time to point out that, if the methods in Great Britain were as intensive as they are in Denmark, the production of wheat, barley, and oats would be more than twice as great in England as it is today and the number of live stock

TABLE B

(COMPILED FROM OFFICIAL RETURNS)

YIELDS OF CEREALS IN 1922

	Denmark	Great Britain	If Great Britain were Denmark
	Tons	Tons	Tons
Wheat	251,715	1,742,000	1,510,290
Barley	662,612	1,096,000	3,975,672
Oats	847,727	1,932,000	5,086,362
	1,762,054	4,770,000	10,572,324

TABLE C

(COMPILED FROM OFFICIAL RETURNS)

LIVE STOCK IN GREAT BRITAIN AND DENMARK

	1923 Denmark	1923 Great Britain Actual figures	1923 If Great Britain were Denmark
	Numbers	Numbers	Numbers
Cattle	2,523,000	7,016,582	15,138,000
Pigs	2,855,000	2,797,633	17,130,000
Sheep	374,000	20,621,256	2,244,000
Poultry	20,029,000	15,123,000	120,180,000

TABLE E

(AGRICULTURAL TRIBUNAL OF INVESTIGATION, P. 31)

NUMBER OF LIVE STOCK PER 100 ACRES OF CROPS AND GRASS, EXCLUDING ROUGH GRAZING, IN THE FOLLOWING COUNTRIES AT PERIODS STATED

	Cattle	Sheep	Pigs	Stock units
France, 1883	13.0	24.0	6.5	17.7
France, 1913	16.3	17.7	7.7	20.4
Germany, 1873	19.5	30.9	8.8	25.7
Germany, 1913	24.5	7.0	26.6	30.8
Belgium, 1880	28.2	7.5	13.2	31.1
Belgium, 1912	40.9	4.1	27.5	47.0
Holland, 1873	28.7	18.0	7.2	32.7
Holland, 1922	37.6	12.2	27.7	44.9
Denmark, 1872	18.7	27.8	6.6	24.0
Denmark, 1922	33.5	6.0	25.3	39.4
Great Britain, 1873	19.2	94.6	8.0	34.3
Great Britain, 1922	22.3	65.4	7.4	33.1
England, 1873	17.5	80.2	9.0	30.7
England, 1922	21.2	43.0	9.0	29.2
Scotland, 1873	25.2	159.8	3.2	48.6
Scotland, 1922	24.2	141.0	3.2	45.0
Wales, 1873	28.3	122.0	7.1	47.2

supported on British farms several times as great as it is at present. As to Table E, most of the European countries have evidently increased the carrying capacity of their grasslands during the last quarter of the nineteenth century and the first quarter of the present century. It is only in the United Kingdom, whose carrying capacity was already high toward the end of the nineteenth century, that there has been no increase in the number of stock units carried per 100 acres of crops and grass. Very marked differences on the score of carrying capacity are found in the countries of Western Europe. For example, we may note that in France 100 acres of crops and grass maintained a little more than 20 units, whereas in Belgium there were maintained in 1912 an equivalent of 47 animal units.

It might be worthwhile perhaps to note one more point that is strikingly brought out in Sir Thomas Middleton's report already referred to. According to him, 100 acres of cultivated land supported shortly before the outbreak of the World War 70 to 75 persons in Germany and only 45 to 50 persons in England. The same area of land produced 33 tons of grains in Germany and only 15 tons in England. Of potatoes there were produced for each 100 acres of cultivated land 55 tons in Germany and 11 tons in England. The corresponding figures for meat and milk are 4.5 tons and 28 tons for Germany and 4 tons and 17.5 tons for England, respectively.

In our own country we may observe certain well-marked tendencies that should help us to define our future policies. Reference may be made, by way of illustration, to the average production of potatoes per acre for the period 1909 to 1913 in some of the individual states and in the United States as a whole. For that period the State of Maine shows a yield of 209 bushels per acre; the State of Texas, 55 bushels per acre; New Jersey 94 bushels, and the United States as a whole, 97.2 bushels. For the period 1914 to 1920 the average yields in Texas were but slightly larger. For New Jersey they increased to 117 bushels per acre and for the United States as a whole to 97.9 bushels per acre. Taking the yields for 1924, we note that the production in Maine was at the rate of 305 bushels per acre; in Texas, 57 bushels per acre, and in New Jersey, 150 bushels per acre.

In view of the fact that soil treatment for the potato crop is more intensive than it is for field crops, the increases just noted are quite suggestive. There has been progress in the use of commercial fertilizers both as to the quantity and quality of the product employed. The more intelligent and more generous use of commercial fertilizers is evidently reflected in larger yields per acre. Many hundreds of experiments with potatoes, wheat, corn, cotton, or other field crops, to say nothing of vegetables, tree fruits and small fruits, may be cited to show how more intensive methods of soil treatment are reflected in larger yields and in greater net returns per acre.

From the standpoint of national policy, we have already reached the parting of the ways. Economists, as well as students of soils, are beginning to recognize that we must intensify our production in order that we may increase the net returns per acre and at the same time rid ourselves of the troublesome problem of crop surpluses. The time has come for us to plan more carefully the return of marginal soils to forests, the maintenance of soils of medium quality in grass wherever live stock farming can be made profitable, and the intensifying of production on that part of our soil area that is of suitable quality and capable of responding to generous applications of chemical fertilizers. In developing a policy of intensification, we should reckon carefully with the factors of climate, crop, soil type, labor costs, location, and the machinery available for marketing and distribution.

The Fertilizer Industry

The fertilizer industry in the United States was, in its earlier years, primarily a scavenger industry. It has become, strictly speaking, a chemical industry. Its leading raw materials consist of phosphate rock, sulfur, potash salts, by-product and synthetic ammonium sulfate, and Chilean nitrate of soda. Products like bone meal, tankage, fish scrap, and cottonseed meal still play a prominent part in our fertilizer industry. Nevertheless, they are rapidly becoming of subordinate importance as sources of plant food. Our fertilizer industry, as at present constituted, aims to supply to the farmers and gardeners combined or mixed fertilizers. Usually, these are so-called "complete" mixtures containing the three ingredients, nitrogen, phosphorus, and potassium. They are sold on a guaranteed analysis in accordance with the provisions of the state laws where the sales are made. A statistical survey of our fertilizer industry will show that there has been a marked tendency within the past ten years toward the manufacture of more concentrated fertilizers, that is, of fertilizers furnishing a greater number of units of available plant food per ton of product. There was a time when fertilizers furnishing only 9 or 10 units of available plant food were sold in large quantities. In recent years the fertilizer manufacturers of the United States have made a determined effort to eliminate the lower analysis mixtures in order that the savings brought about in the manufacture of more concentrated mixtures might be credited both to the industry and to the consumer. There has been friendly coöperation between the fertilizer industry, on the one hand, and the commissioners of agriculture and the state agricultural colleges and experiment stations, on the other, in emphasizing the advantages that may be derived from the use of mixtures containing a relatively high number of units of plant food. As a result of the educational work that has been done in this field, mixtures containing 15 to

20 units of available plant food can be readily had by purchasers of commercial fertilizers.

The relative proportions of the three ingredients in commercial fertilizers vary within wide limits. It has been noted, however, that mixtures containing an equivalent of one part each of ammonia and potash and of two parts of phosphoric acid give good results under average conditions. For crops showing an especially ready response to potash (as is true of potatoes or tobacco) a higher proportion of potash is used. For crops like early potatoes or vegetables, the proportion of ammonia in the mixture may be relatively much higher. The soil type, the crop history of any particular field, the system of farming in vogue and the prevailing market prices of agricultural commodities all serve to influence the amount and quality of the commercial fertilizer used.

As a chemical industry the manufacture of fertilizers is of outstanding importance. In 1925 there were produced in the United States, in round figures, about $7^1/_2$ million tons of commercial fertilizers. A part of the raw materials, notably phosphate rock, sulfur, some of the potash, and a large part of the nitrogen were of domestic origin. On the other hand, we imported, in 1925, materials representing a total value of about 78 millions of dollars. Of this amount Chilean nitrate of soda represented a value of more than 52 millions of dollars, and German and French potash salts and a number of other raw materials represented a value of approximately 25 millions of dollars. It would be well to note here that, notwithstanding the upward trend of commodity prices, the cost of plant food to our farmers is either below that of the pre-war years or but slightly greater in the case of one or two of the raw materials. The decrease in the cost of fertilizer nitrogen has been particularly marked. This remark will apply to Europe as well. For example, the cost of sulfate of ammonia in England rose from about $80.00 per ton in 1917–1918 to about $110 per ton in 1919–1920. Since that time, there has been a very striking decline in the market price of this commodity. Thus, in 1921–22 it was quoted at about $65.00 per ton; in 1923–24, at less than $60.00 per ton; in 1925–26, at less than $50.00 per ton on a product containing approximately 20.5 per cent of nitrogen. In Germany, thanks to the development of the production of synthetic nitrogen compounds, sulfate of ammonia, which is practically chemically pure, may be bought, at the consumer's station, at about $40.00 per ton.

Much work has been done by our experiment stations on the use of nitrogen-carrying materials for the production of different crops and on different soils. It has been shown that there are marked differences in the efficiency of different forms of nitrogen. Depending on the crop, soil, and climate there are more or less marked differences in the efficiency of the nitrogen in nitrates and in ammonium salts. Differences between

the efficiency of nitrogen in products of animal or vegetable origin, on the one hand, and in nitrates and ammonium salts, on the other, are very much more marked. Nevertheless, organic nitrogen still commands a much higher market price even though its agricultural or crop value is much less. Our fertilizer industry, as well as the buyers of commercial fertilizers, are rapidly coming to appreciate the significance of the differences just noted. This is certain to be reflected in the prices of the various forms of nitrogen.

Synthetic Nitrogen

Interesting information on the world resources of by-product and synthetic nitrogen in the fertilizer industry is given in the Sixth Annual Report of the British Sulphate of Ammonia Federation, Ltd. The following table offers much that is suggestive.

WORLD PRODUCTION OF NITROGEN IN TONS OF 2240 LBS. OF PURE NITROGEN, FOR THE YEAR ENDING MAY 31, 1926

	1923/24	1924/25	1925/26
By-Product Sulfate of Ammonia	275,000	290,300	305,700
Synthetic Sulfate of Ammonia	231,000	254,800	289,000
	506,000	545,100	594,700
Cyanamid	104,000	115,000	150,000
Nitrate of Lime	18,000	25,000	30,000
Other Forms of Synthetic Nitrogen	58,000	66,000	119,000
Other Forms of By-Product Nitrogen	30,000	32,400	27,500
Total production	716,000	783,500	921,200
Deliveries of Chilean Nitrate of Soda in Consuming Markets	340,000	363,000	324,200
	1,056,000	1,146,500	1,245,400
Estimated Total for Agricultural Consumption	900,000	983,100	1,072,000

As the stocks of by-product and synthetic forms of nitrogen were not heavier in May, 1926, than at the end of the previous consuming season, the increased production of synthetic forms of nitrogen shown by the above figures may be regarded as having been consumed.

It will be noted that within the past three years there has been a very marked increase in the production of both synthetic and by-product sulfate of ammonia. The total of the two represented 506,000 long tons of pure nitrogen in 1923–24, and 594,700 tons in 1925–26. The amount of cyanamid nitrogen increased during the same period by nearly 50 per cent. Other forms of synthetic nitrogen (among them, ammonium sulfate nitrate, calcium nitrate, urea, potassium nitrate, sodium

nitrate, ammonium chloride, and other salts) bring the total up to very respectable proportions. It is estimated by the author of the report that for agricultural consumption there were available in 1923–24, 900,000 long tons of nitrogen whereas in 1925–26 the total was equivalent to 1,072,000 tons.

It was stated by Dr. Bueb, of the Stickstoff-Syndikat, at the International Nitrogen Propaganda Meeting at Biarritz in April, 1926, that Germany would produce in 1926–27 about 500,000 tons of synthetic nitrogen, equivalent to 3,000,000 tons of sulfate of ammonia. It was also stated by him at that meeting that in 1923–24 Germany exported an equivalent of 28,000 tons of nitrogen; in the following year, an equivalent of 52,000 tons, and in 1925–26, about 135,000 tons of nitrogen. The products exported were represented by ammonium sulfate nitrate (Leunasalpeter), potassium ammonium nitrate, cyanamid, urea, and calcium nitrate. Experimental work is in progress which would indicate that diammonium phosphate and mixtures of ammonium sulfate and diammonium phosphate will be supplied in the near future by the Stickstoff-Syndikat in very substantial quantities. It is interesting to note that the diammonium phosphate contains 19 per cent of nitrogen and 47 per cent of phosphoric acid. This is sold by the Stickstoff-Syndikat under the trade name "Diammonphos." The product Leunaphos, representing a mixture of ammonium sulfate and diammonium phosphate, is guaranteed to contain 20 per cent of nitrogen and 15 per cent of phosphoric acid. The product designated as Leunaphoska is guaranteed to contain 13 per cent of nitrogen, 10 per cent of phosphoric acid, and 13 per cent of potash, and is intended largely for export to the Far East. Special attention may be called to the fact that the diammonium phosphate in question contains a total of 66 units of plant food; the Leunaphos, a total of 35 units of plant food, and Leunaphoska, a total of 36 units of plant food. From the standpoint of handling and transportation, these products should be relatively cheap.

The increased supply of synthetic nitrogen products and the lower cost of nitrogen in commercial fertilizers has undoubtedly stimulated consumption. As was noted by Speyer at the Nitrogen Propaganda Meeting at Biarritz, France used but a few years ago only 2.60 pounds of nitrogen per acre of arable land as compared with 4.53 pounds for the United Kingdom and 10.3 pounds for Germany. He gives the following comparison.

	Arable acreage in millions of acres	Consumption of pure nitrogen Lbs. per acre	Total per annum in tons
Germany	67	11.2	335,000
France	54	4.5	108,000
United Kingdom	14	5.6	35,000

In commenting on the above figures, he says: "Owing to the special conditions prevailing in Belgium, Denmark and Holland, the consumption of nitrogen per acre in those countries is very much higher, being from twice to three times the German average.

"It has required overwhelming economic pressure to raise the consumption of nitrogen in Germany and France (and to a lesser extent in England) to its present level, because these countries were able before the war to count on their exportable surplus of manufactured goods to provide them with food stuffs which could be grown more cheaply in countries on the periphery of the economic world.

"The question therefore arises whether the increase in the output of nitrogen in Germany, France, England, and the rest of Europe to a point at which it is possible to provide countries on the economic periphery with relatively cheap supplies of nitrogen will not ultimately produce a reaction unfavorable to home consumption in the producing countries.

"If the figures given in the extremely interesting and comprehensive Nitrogen Survey published by the United States Department of Commerce a few years ago can be considered as typical for other great countries which are only now commencing to consume nitrogen on a large scale, there is little doubt about the answer to this question."

The Place of Nitrogen in Conservation and Production Programs

Because of the increasing supplies and declining costs of combined nitrogen for fertilizer purposes, systematic efforts will be made, and indeed are now being made, to expand the markets for fertilizer nitrogen. It is recognized that within economic limits the present consumption of nitrogen in agriculture is but a small fraction of the possible consumption. Without going far afield for illustrations, we might note the interesting experiments that were initiated by Prof. Warmbold at Hohenheim, near Stuttgart, Germany. In 1916 he divided 69 acres of pasture into ten areas of from 4 to 10 acres each. These were fenced in and used for a study of the carrying capacity of the pastures under different conditions of treatment as to applications of artificial fertilizers. At the beginning of the experiment 1.4 acres were required for the maintenance of one cow of 1100 pounds from the end of April to the beginning of October. Beginning with the winter of 1916–17, the pastures have been treated with an equivalent of 107 pounds of nitrogen per acre in addition to applications of phosphates and potash salts. The phosphates and potash salts are usually applied in the fall; one half of the nitrogen, in the form of sulfate of ammonia, about the first of February, and the other half in three separate applications, usually in the form of urea, in May, June, and July. It is noted in the September, 1926, issue of the *Journal of the Ministry of Agriculture of Great Britain* that "The effect of this heavy manuring

was seen in 1917, when an area of $^3/_4$ acre was sufficient for one cow. From 1918 onwards $^1/_2$ acre per cow sufficed." It is further noted in the same journal that "Doubts have been expressed as to how far the results obtained by Dr. Warmbold were due to improved methods of pasture management, and how far, if at all, to nitrogenous manuring. The most skeptical, however, after seeing Dr. Warmbold's plots, would be convinced that no system of management which omitted the use of nitrogenous manures could produce such luxuriant herbage as that at Hohenheim; and the effect cannot be attributed to manurial residues of feeding stuffs, because no cake or corn is fed to the cows in summer, whatever their milk yield may be."

Similar experiments are being carried out in England. It is reported by T. H. J. Carroll ("The New System of Grassland Management") that "At Tollesby Farm, where the experiment on twenty-seven acres was commenced in December, 1925, remarkable results are being obtained. The stock-carrying capacity of the grass prior to the experiment was about five cows to every six acres, and the 27 acres carried 22 head of stock. On the 15th of June, 1926, the twenty-seven acres were carrying 45 heavy milking cows and 21 head of dry stock, a total of 66 head, which is about equivalent to five cows to every two acres. Noteworthy features in connection with this Yorkshire trial are that grazing commenced thirty days earlier than formerly, the manurial treatment and heavy stocking have eliminated from the pasture all the rough and coarse patches resulting from horse grazing in previous years, and the clovers on the whole of the 27 acres are more in evidence than formerly."

Without multiplying the evidence, it would suffice to observe here that the more abundant supply of technically fixed nitrogen, its lower cost and its varied forms are certain to be significant factors in bringing about far-reaching changes in the agricultural practices of the United States. With the aid of nitrogenous and other fertilizers, we shall increase the average acre yields, diversify our farming, restore our forests, approach a solution of the problem of agricultural surpluses, and, in general, bring to our agricultural population more efficient production, greater net returns, higher standards of living and a greater degree of stability and contentment that should be reflected in our national well-being and progress.

THE STORY OF A GRAIN OF CORN. III. ECONOMIC IMPORTANCE OF CORN AND THE CORN PRODUCTS INDUSTRY

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At the session of Congress just ended, a bill was passed appropriating ten millions of dollars for the protection of the corn crop against the ravages of the corn borer—striking evidence of the economic importance of corn to the nation. The money value of the corn crop of the United States is greater than that of any other agricultural product. This value is one of the most important factors entering into our national prosperity. The distribution and final disposition of this great American cereal, which, as has been shown, is the crude material for one of our basic industries, are of peculiar interest to chemists.

For the past four years, 1923–26, the corn crop of the United States has averaged about 2,714,000,000 bushels annually. Compilers of agricultural statistics report that eighty per cent of the crop is consumed in the counties where grown, and twenty per cent is shipped to outlying points; only ten per cent of the total production reaches the primary markets, and two per cent is exported.

"The price of corn in any year is not determined so much by the size of the total crop as it is determined by the quantity that reaches or is likely to reach the *primary markets*. There is only a limited demand for commercial corn. During the last ten years the receipts at primary markets have averaged about 260,000,000 bushels." (Malcolm C. Cutting, *The Country Gentleman*, Nov., **1926,** p. 42.) According to this authority, less than 10 per cent of the average crop for ten years determined the price of corn.

The corn products industry, exclusive of the fermentation industry, has assumed rather large proportions within comparatively recent years. There are now in operation eleven companies in the United States using American corn as the crude material for the manufacture of corn starches, dextrines, sugar, sirup, oil, and cattle feed as principal products. These companies ground more than seventy-six million bushels of corn during the year 1926. To be sure, less than three per cent of the total corn crop of that year, but about twenty-eight and one half per cent of that portion of the crop which determines the price of corn, "cash corn."

Associated Corn Products Manufacturers, composed of eleven manufacturing concerns, reported the production for the year ending December, 1926, as:

Corn Sirup (glucose, sold as such)	864,959,338 lb.
Corn Sirup (used for mixed sirups, jams, jellies, etc.)	244,057,550 lb.
Corn Sugar	696,838,194 lb.
Corn Starch in Bulk	686,440,810 lb.

Corn Starch in Pkgs. (for laundry, edible, etc., purposes)	149,309,804 lb.
Dextrines	92,937,403 lb.
Crude Corn Oil	37,876,516 lb.
Refined Corn Oil	66,142,286 lb.
Corn Gluten Feed and Gluten Meal	576,890 tons
Corn Oil Cake and Cake Meal	23,031 tons
Miscellaneous Products	68,347,536 lb.

In spite of these imposing figures, there is a surplus of corn. That is to say, the supply of corn is so great that it cannot be sold at a price which will give the corn grower an adequate return for his labor and investment, and, in many cases, it is claimed the price is below the cost of production. The farmer is dissatisfied and demanding some form of relief or readjustment of economic conditions. The politicians offer a McNary-Haugen bill, the U. S. Department of Agriculture advocates the exportation of corn, and the corn grower still wonders what is going to happen. A discussion of the various farm relief measures will not be attempted. Under present world conditions, the exportation of corn grown in the United States in anything like adequate quantity is an economic impossibility. During the years 1923–25, less than twenty-five million bushels were exported, and almost half of this was taken by Canada, Cuba, and Mexico, really adjacent markets.

Plants in European countries manufacturing corn products consumed during the three years of their existence more than $10^1/_2$ million bushels of corn, of which only 4.22% was U. S. corn, because the price of foreign grown corn in foreign markets was lower than the Chicago price plus freight and charges. This is the record. For 1924, foreign corn was from $14^1/_2$¢ to $6^1/_3$¢ lower than U. S. corn; in 1925, $16^1/_3$¢ to $7^2/_3$¢ lower; for ten months of 1926, $8^2/_3$¢ to $7^1/_2$¢ lower at two principal European ports.

Corn for overseas export must be of a standard moisture content, and lower grades must be processed to meet these requirements, which means an additional expense varying with the condition of the grain. For example, in October, 1926, No. 2 Argentine corn was selling at European ports for 82 cents per bushel delivered, and at the same time No. 5 corn sold in Chicago at $67^1/_2$ cents. Freight and charges, but without the expense of processing, would give a cost of $103^1/_2$¢ to $100^3/_4$¢ for U. S. No. 5 corn at European ports, or a difference of $21^1/_2$¢ in favor of No. 2 Argentine.

Foreign countries producing corn have not developed up to the present time important corn-consuming capacity. They have no corn products industry nor do they convert corn into hogs to any great extent. Practically the entire crop is available for export and must be exported in order to realize any return. The result is that there is no real price in foreign markets for this foreign grown corn. The price, except in very exceptional cases

has always been the U. S. price minus whatever is necessary to make the sale.

Any proposal to export U. S. corn, irrespective of price—in other words, "dump" the so-called excess and prorate the loss among producers, is economically impossible and will defeat its own purpose. This is proved by past experience. The U. S. corn products industry is exporting to the United Kingdom of Great Britain and other European countries in which corn products are not manufactured at the rate of ten million bushels per annum, in the form of products made in the U. S. from corn grown in the U. S. The export of such products to other parts of the world further increases this outlet. When the foreign markets are flooded and the price in foreign markets is in consequence depressed, corn is imported into the U. S. in bond, converted into exportable products, and the duty on the corn used for this purpose is refunded. There have been many importations of foreign corn. At one time these importations closely approached eleven million bushels during a period of two years. It is clear that a pronounced depression of the foreign price has injured the U. S. grower, and this will always be the effect. Furthermore, should such depression of the price of corn become an established commercial practice, not only must the exportation of U. S. manufactured corn products cease, but the corn-producing foreign countries would be forced to consume their own corn and export converted products either in the form of manufactured products, or hogs, or both.

"Anyone who has advocated the export-corporation plan of agricultural relief as a measure that will improve the situation of corn is ignorant of his subject or is merely playing upon the credulity of his hearers." (Malcolm C. Cutting, *The Country Gentleman*, Nov., **1926**, p. 42.)

The economic situation caused by the so-called over-production of any commodity must be met either by a curtailment of production or by the creation of new outlets, thereby increasing the demand for the commodity. This latter course appeals especially to the chemist and is the logical one when large economical productive capacity exists.

Let us examine the situation of corn sugar in this connection. As has been shown in a preceding discussion, the wholesomeness, purity, and nutritive value of corn sugar have been established—these facts have been accepted by the Bureau of Chemistry. Naturally, the corn growers and corn sugar manufacturers expected that the wider use of an American-grown and American-manufactured product would be abetted and encouraged by the U. S. Department of Agriculture. These authorities have said, in effect—"we have established (arbitrarily) standards for certain food products which do not provide for the use of corn sugar and we will not change these standards."

When it became established that pure dextrose could be manufactured

in quantity at a low cost, the U. S. Department of Agriculture was appealed to for a modification of certain definitions so that corn sugar would be granted the same freedom of use as an ingredient of food products as is enjoyed by cane or beet sugar, sucrose. The power to do so is recognized and exercised through the Food Inspection Decisions. Such appeals have been uniformly denied—not on the ground that dextrose is impure, unwholesome, injurious, but because the public is supposed to believe that sweetness is derived only from sucrose and the danger flag through a warning label must be raised against any other sugar.

At one time only olive oil could be used in preparing mayonnaise dressing and packing sardines, without label mention, now the Department of Agriculture permits the use of any edible oil in these products, notwithstanding the fact that at least some consumers still believe that only olive oil is permissible.

As corn sugar became better known and its food value recognized, the corn growers realized that it was being discriminated against in favor of cane and beet sugar, and since the U. S. Department of Agriculture remained obdurate, a movement for direct legislation was started by the corn-growing states. As a representative of these interests, the late Senator Cummins of Iowa introduced a bill in the U. S. Senate and, likewise, Congressman Cole of Iowa in the House of Representatives, to amend the Pure Food Law, providing that a product should not be deemed misbranded or adulterated "because of having been sweetened or preserved with an article commonly known as corn sugar." This was amended by adding "also with an article known as fruit sugar or levulose." The bill in this form passed the Senate with practically no opposition. The House bill was referred to the Committee on Interstate and Foreign Commerce. Representatives of the corn products industry were invited to testify at the hearing, but declined on the ground that while in this case the interests of the corn growers and corn sugar manufacturers were identical, still the amendment to the Pure Food Law was championed by the representatives of the agricultural interests for the purpose of extending the market for corn, and the political situation made it unwise to inject industrial interests. The amendment was not blessed with the sanction of the Department of Agriculture. It was not to be expected that the Committee would report favorably a bill of this nature when opposed by the Department of Agriculture. Of course, there was no foundation for the charges that this bill was an attempt to emasculate and destroy the Pure Food Law, to permit the adulteration of sugar and honey, to allow corn sugar to be sold as cane sugar. Corn sugar should never be sold for anything else but corn sugar, and when it is so sold the buyer should be permitted the same freedom of use as is allowed cane or beet sugar. The bill as reported out of Committee was entirely

different from the original one. It provided "that confectionery, frozen products, products of the bakery, meat or meat products shall not be deemed to be misbranded or adulterated under the provisions of this Act for failure to declare the presence of sucrose, dextrose, maltose or levulose," etc. This meant that in all other products only sucrose could be used without label mention. That jelly, jam, preserve, canned fruit and vegetables, beverages, etc., containing say from twenty to fifty per cent of sugar can be made only with sucrose without label mention, while confectionery containing upwards of ninety per cent might be made from any form of sugar, is at least extraordinary. Why dextrose should be permitted in ice cream, but not in sweetened condensed milk, from which ice cream is often made, still remains a mystery.

Under date of April 8, 1926, the Secretary of Agriculture wrote the Committee as follows:

> I have never been opposed, and in fact in my letter to you of March 31, I suggested the advisability of a modification of Congressman Cole's bill so as to place corn sugar on an equal basis with any other sugar. This can be done by requiring a declaration on the label of food products of any sugar which may be used as an ingredient in its preparation or packing.

Such a provision could not be passed on account of disclosing special formulas. The Secretary further stated:

> Trade custom and the character of the products, in my judgment, justify these specific exemptions. (Confectionery, frozen products, products of the bakery, and meat and meat products.) I do not feel, however, that milk products or canned fruits and canned vegetables should be included.

At any rate the bill in this amended form passed the House, but has never been voted on by the Senate.

The political aspect is at least "foggy." The economic consideration affords a clear direct issue.

The present sucrose consumption of the U. S. is approaching twelve billion pounds per annum. Of this, we produce about 18.6% within the country, import 22.7% from our insular possessions, and 58.7%, or more than seven billion pounds, from foreign countries. We are paying for this about $360,000,000 annually, almost one million dollars per day, to foreign countries. On account of difference in sweetness and solubility, corn sugar will replace only a limited amount of our sucrose consumption so that home production and importations from our insular possessions will not suffer. The tariff takes care of that now.

Freed from the present hindering discrimination against corn sugar, the corn products industry, on a conservative estimate, would consume approximately twenty million bushels more of corn annually. It was shown above that the industry is at present consuming about 28.5% of the "cash corn." Increase this by twenty million bushels and the con-

sumption by the industry reaches 35.5% of the "cash corn," an increase of about 25% over the present figure. This extra demand can have only one effect upon the market price of corn. It is clear that broadening the arbitrary definitions without amending the Pure Food Law, which manifestly could be done without detriment to the consuming public, would mean broadening the market for corn by increasing the demand, and a higher price to the corn grower must result. This remedy is positive and direct. What an encouragement to chemical industry would be the official recognition of this great achievement which provides a new outlet for a product of American agriculture through American industry!

Advertise for Scientist to Preserve Children's Curiosity. "Wanted—a scientist of the first order, if necessary of senior standing, but as young as possible, with a knowledge of the theory of science, to investigate and conduct the introduction of young children, $4^1/_2$–10, to science and scientific method."

This is not a peep into the notebook of a modern novelist planning another version of an ultra-scientific Utopia but an actual bona fide advertisement that has appeared in leading periodicals and newspapers of Great Britain. Through it prominent educators hope to hit a decisive blow on the head of the weak nail in the top heavy structure of modern education.

Directors of the Malting House School at Cambridge are convinced that the active interest of early childhood loses its keen edge after a few years spent under instruction according to present educational methods. They believe that the emotional and intellectual drives, "usually grouped together in the term curiosity, exist in the early lives of most people, and that their striking loss in later years rendering many born with good brains intellectually ineffective and tired of life, is due to some large extent to laming by early influences. The most consciously held aim of the educator should, therefore, be to avoid damaging these drives, and lest his life should pass in loading ships with ballast, to rank that aim before that of the installation of knowledge—particularly in the early years when relatively little knowledge can be instilled and great damage done."

Preliminary work with children of faculty members of Cambridge University at Malting House School has been sufficiently successful to encourage the directors to further its development.

"At present," they state, "there is no recognized, infallible or easily-applied technic for the preservation of curiosity during education, and it is not least for the investigation of this, one of the social problems of the age, that the directors hope to make of the appointment advertised the beginnings of a research institute. Nevertheless they believe that the learning of how to learn and a scientific scrutiny of familiar things, an attitude of critical curiosity and intellectual aggression to the unknown, requires to be preceded by the discovery of the idea of discovery."

To date replies have been received from 7 professors and university lecturers, 62 workers in other branches of science, 47 with other qualifications, and 39 without any qualifications. Sir Ernest Rutherford, former winner of the Nobel prize for physics and director of the Cavendish Laboratory of physics at Cambridge, Professor Percy Nunn, well-known educational author, and J. B. S. Haldane, biologist and essayist, will assist in making the final selection of candidates.—*Science Service*

IONIZATION AND THE ATOMIC STRUCTURE THEORY IN ORGANIC CHEMISTRY

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When the chemistry student makes the jump from inorganic and analytical chemistry into the field of organic chemistry he is likely to have to leave behind the ions and the ionic reactions with which he has at least cultivated a speaking acquaintance. Even in recent years it has not been uncommon for a student to cover the whole field of organic chemistry without hearing more than a mention of ions or ionization. Sometimes he is told that organic compounds do not ionize and sometimes he is left (not without some justification) to wonder whether they do or do not.

A common sense view of the situation in the light of modern theories of atomic structure makes it unnecessary longer to dodge the question of ionization. In organic as well as inorganic chemistry the question can be discussed frankly with profit. Present-day theories of atomic structure have clarified the subject in both fields so there is no need for conflicting ideas.

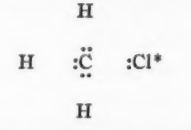
The field of inorganic chemistry cannot claim monopoly on the ionizing substances because all organic acids, bases, and salts ionize just as do the corresponding inorganic compounds. Neither can the field of organic chemistry claim a monopoly on the non-ionizing substances, because there are a good many non-electrolytes among the inorganic compounds. Perhaps the most important of these are the various acid anhydrides, which produce ionizing acids only after hydrolysis It has been suggested elsewhere[1] that many organic compounds show resemblances to these acid anhydrides. Conclusive evidence was presented to show that alcohols ionize as very feeble acids, and that their tendency to ionize as bases, if it exists, is negligible in comparison. In accordance with this fact an ester may be regarded as a mixed acidic anhydride, which produces on hydrolysis an acid (in the ordinary sense) plus an alcohol which has very faint acid properties. Many other organic compounds can reasonably and profitably be considered in a similar light.

One of the striking features of organic chemistry is the fact that extreme cases often present themselves. Thus we find extremely complex compounds and reactions, and often extremely unreactive compounds. The alcohols with their very feeble ionization present an extreme case and the simple anhydrides of the alcohols (ethers) are extreme cases of acidic anhydrides which are very unreactive. The generalization which has previously been suggested applies: anhydrides of stronger acids (whether inorganic or organic) are more reactive while anhydrides which produce weaker acids on hydrolysis are, in general, less reactive. The ethers,

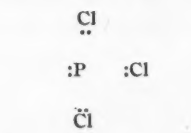
[1] *J. Am. Chem. Soc.*, **45**, 1353 (1923); *Univ. Oregon Publ.*, **2**, No. 3 (1923).

esters, acid anhydrides, acyl halides, and many other organic compounds fall in line with this general rule.

One set of phenomena among the non-ionizing organic compounds has been responsible for much speculation and not a little difficulty, namely the "positive" or "negative" behavior of atoms or groups which are not present as ions. That an element in an organic compound may be negative without separating as a negative ion is not at all incongruous in terms of the Lewis theory of atomic structure. A pair of electrons between the atoms constitutes the chemical bond or co-valence. Because of the different character of the elements concerned this pair of electrons may be drawn more toward one atom than the other, in which case one atom is in a very real sense negative with respect to the other and yet may undergo no ionization. For instance, the condition in methyl chloride may be represented in perhaps an exaggerated way as follows:



The bonding pair of electrons is drawn closer to the chlorine nucleus than to the carbon nucleus so that when sodium hydroxide reacts with methyl chloride it is not a matter of chance that the positive sodium becomes attached to the negative chlorine. Yet there is no evidence that chlorine ions ever separate and move independently in the methyl chloride itself. In phosphorus trichloride (or other non-metallic chloride) the situation is probably like that in methyl chloride. The chlorine has more attraction for the electrons than does the phosphorus and we may represent the situation thus:

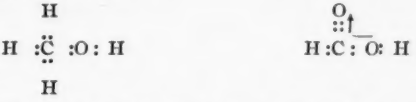


Here again ionization probably does not take place, yet the chlorine shows by its chemical behavior that it is negative with respect to the phosphorus. In the case of sulfur trioxide the situation is probably analogous. Oxygen is negative (draws the electrons away from the sulfur) yet the reaction of sulfur trioxide with water to form sulfuric acid is obviously not preceded by the separation of oxygen and sulfur ions. These ideas in regard to the negativity and positivity of groups in compounds, which have been very briefly outlined, make possible the inter-

* In this and most of the following formulas only the co-valence electrons are represented, in order to avoid confusion.

pretation on a rational basis of many reactions of organic compounds where ionization probably does not precede the reaction.

A consideration of the ionizing organic compounds which are very numerous, is also worthwhile from the standpoint of ultimate molecular structure. One of the important contributions of the modern theory of atomic structure is a better understanding of the factors which promote ionization. For example, in terms of atomic structures, we have a definite reason for the fact that formic acid ionizes to a considerable extent while methanol is an extreme case and ionizes very little. The two structures may be represented as follows:



In the case of formic acid the oxygen atom pulls the electrons toward its nucleus, causes a shift in the electrons throughout the molecule in the direction indicated by the arrow, and thus allows the hydrogen nucleus (ion) to separate more readily from the oxygen.

Again, in the chloroacetic acids, for example, the chlorine atoms cause an electron shift in their direction and thus allow the hydrogen ions to form more readily, as indicated below.

The same factors apply generally to acids and bases of varying strength whether organic or inorganic and the same interpretation serves to explain the differences in their strength.

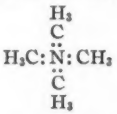
The behavior of ammonium and other analogous "onium" compounds is much clarified by the application of the modern theory of atomic structure. For example, in basic properties the primary ammonium bases are stronger than ammonium hydroxide itself, the secondary bases are still stronger, but the tertiary bases are weaker than either the primary or secondary. The quaternary ammonium bases, however, are much stronger than any of the others. In fact, all of the quaternary bases, whether ammonium, phosphonium, arsonium, or stibonium, are comparable in strength to sodium hydroxide. In other words they are probably completely ionized. According to the Lewis theory this basic strength is due to the stability of the bases, and the apparent weakness of ammonium hydroxide and primary, secondary, and tertiary ammonium bases is due entirely to their instability. According to this theory which is substantiated by the best evidence available, an ionizable hydroxyl group or chlorine atom is never held by a nitrogen atom, but the corresponding

ions may be held by electrostatic attraction to the ammonium ion. Ammonia and the ammonium ion may be pictured as follows:

NH_3

NH_4 ion

In ammonia the "octet" of the nitrogen is complete but there is a pair of unengaged electrons which may hold a hydrogen ion, thus forming the ammonium ion. This addition of hydrogen ion is, however, reversible. In the presence of water which furnishes few hydrogen ions an appreciable amount of ammonia may exist in the uncombined state. In the presence of acids which furnish high concentrations of hydrogen ions the ammonia does not exist as such but as ammonium ions. In the case of the quaternary ammonium bases, the hydrogen atoms are all replaced by alkyl groups, and no alkyl group can break off readily as the hydrogen atoms do in the simpler bases. The structure of the tetramethyl ammonium ion may be represented in abbreviated way as follows:



No compounds are known containing this ion or analogous completely substituted "onium" ions which are not completely ionized. The corresponding hydroxides are strong bases while the partially substituted unstable ammonium bases are weak, due to the instability of the ions, and their tendency to separate into hydrogen ions and amines.

There are several other applications of the ideas of atomic structures to various fields of organic chemistry which could be discussed if space were available. The addition of acids to unsymmetrical unsaturated compounds has been found to take place in accordance with this theory. The fruitful idea of partial valence is readily interpreted in terms of atomic structures. The existence and properties of free radicals is clarified by the application of the Lewis theory, and even the difficult problem of substitution in the benzene ring has been attacked with some success from the same viewpoint.[2]

The status of the present theory of atomic structure is a fairly stable one. There is now common ground upon which physicists and chemists may meet and each group is recognizing the validity of the other's work. Atoms are not thought by either chemists or physicists to be static systems. The simple picture first presented by Lewis and by Langmuir is not satisfying, though there is an important germ of truth present.

[2] See G. N. Lewis, "Valence and the Structure of Atoms and Molecules," A. C. S. Monograph; Lucas and Moyse, *J. Am. Chem. Soc.*, **47**, 1459 (1925); Pauling, *Ibid.*, **48**, 1132–43 (1926); Lucas, *Ibid.*, **48**, 1827–38 (1926).

Neither can the strictly planetary systems of the physicists be defended successfully in view of the fixed nature of chemical unions in organic compounds. Yet the orbital motion of electrons is generally agreed upon. As Lewis pointed out, we may consider the position of the orbit of the electron as the position of the electron itself, in which case the deductions from the static atom may apply, provided that the electrons do not have the nucleus as the center of the orbit. Physicists seem willing to admit in view of known facts that the valence electrons at any rate have more or less fixed orbits with centers outside the nucleus. The more strictly planetary system may hold for the electrons of the kernel.

The position of the present theory of atomic structure is thus fairly secure even though subject to modification. All texts on general chemistry make use of the theory and there is agreement on all essential points. The applications of this theory to the field of organic chemistry are no less fundamental and far reaching than the applications to inorganic chemistry, and it would be unfortunate if organic chemists failed to make use of this important contribution.

No One Knows Why Cod Livers Have Vitamins. Chemists are trying to find out where codfish get the vitamins that made cod-liver oil famous.

Exposure to ultra-violet rays, which has been shown in the case of cows to increase the vitamin D content in dairy products, does not work with fish, declares Charles E. Bills, research chemist of Evansville, Ind., in a report that will appear in a forthcoming issue of the *Journal of Biological Chemistry*. Fish subjected to five-minute exposures of ultra-violet irradiation every other day for six weeks produced oil that displayed no more potency than that made from fish which had not been so treated.

During the period in which the Newfoundland codfish fattens, it gorges itself on small fish known as caplin which contain only a small amount of vitamin D. To account for the unusually high potency of cod-liver oil the cod would have to consume, within a period of four weeks, about 26 times its weight of caplin, a most unlikely quantity.

The presence of vitamin D in the liver of fish consequently is judged to be the result of chemical reactions in the body of the fish at present not clearly understood.—*Science Service*

Shows How Roots Get Air to Breathe. Plant roots no less than plant leaves need to breathe, and the rate at which oxygen can move through the soil is a highly important thing for scientific farming to know, according to Dr. Lee M. Hutchins of the U. S. Department of Agriculture. Before the meeting of the First International Congress of Soil Sciences at Washington, Dr. Hutchins demonstrated the operation of an apparatus which he devised to measure the oxygen-supplying power of the soil.

The essential part of the apparatus is a hollow vessel of porous porcelain, buried in the soil to be studied. Pure nitrogen is passed through it, and the outgoing stream is bubbled through a chemical solution that changes color if there is any oxygen present. The shade of the solution after a given time indicates the amount of oxygen that has passed from the soil through the walls of the porcelain vessel and into the nitrogen stream.

Dr. Hutchins has been using his invention to study the oxygen needs of such typical crops as corn and wheat, and also such plants as rice and willow trees, which can grow in soils that are waterlogged and hence very low in oxygen.—*Science Service*

ADDITION REACTIONS OF CONJUGATED DOUBLE BONDS

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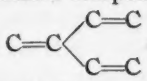
The addition reactions of compounds possessing a single pair of double bonds are so well explained by the theories of Baeyer,[1,*] Wunderlich[2] and Victor Meyer[3] that one is surprised at the complex nature of the phenomenon of unsaturation in substances with two pairs of adjacent double bonds. In 1899 Johannes Thiele[4] published an article in which he set forth a theory to explain the properties of these compounds that contain what he calls a "conjugated system," C=C—C=C. This article has been the inspiration of so many investigators that it has been considered the beginning of modern interest in valence,[5] and certainly a study of the addition reactions of conjugated systems will throw light upon several points of theoretical interest keenly alive today. The existence of polarity in a double bond has been shown;[6] from the reactions of conjugated double bonds much information about the polarity of the unsaturated system can be gained; even a superficial observation of the reactions will disclose the fact that the distribution of valence forces in the system changes with each alteration in either the spatial arrangement or the chemical nature of the groups attached.

The literature on the subject of conjugated double bonds is so extensive that it will be necessary to limit the present article to reactions of hydrocarbons containing the system C=C—C=C and to α, β-unsaturated aldehydes, nitriles, acids, esters, and ketones. The type of addenda to these six systems has also been limited: the reactions of Grignard's reagents with these type compounds have been the subject of so many investigations that reference to them will have to be omitted. Finally, mention only can be made of the application of Thiele's theory to the problems of substitution in the benzene nucleus; an excellent review of this phase of the subject has recently appeared.[7]

Before entering upon a critical discussion of Thiele's hypothesis it might be well to note two of the unusual physical properties of conjugated double bonds, which mark them as constituting a system of remarkable activity. J. W. Bruhl[8] has shown that the presence of a conjugated system is readily indicated by the exaltation of molecular refraction. He explained the fact that benzene and all its derivatives are exceptions, by assuming that the equally situated ethenoid groups neutralized one another. In supporting this he pointed out that after the insertion of another atom or radical between two of the six carbon atoms of the benzene nucleus (as in the case of tropilidene where CH_2 is inserted into the ring), the resulting compound showed the typical exaltation of refraction. K. von Auwers[9] extended Bruhl's rules of optical behavior to many types

* Numbers refer to bibliography at the end of this article.

of unsaturated compounds. He showed that "crossed" double bonds of the type  displayed much less exaltation of specific refraction and dispersion than the straight chain conjugated systems, and that each additional conjugated system in the latter increased the exaltation about three-fold. He also determined the fact that the introduction of substituents into the system tends to reduce to some extent the exaltation.

Auwers'[10] investigations of the relation between the constitutions and the heats of combustion of unsaturated compounds determined the facts that compounds with conjugated linkages always have smaller heats of combustion than those in which the olefine linkings are not in conjugated positions, and that the presence of substituents attached to the carbon atoms of the conjugated system always increases the heat of combustion.

From these results of the investigations of Bruhl and Auwers on the physical properties of conjugated double bonds it should not be surprising to find that compounds containing such systems show chemical properties quite out of the ordinary for unsaturated substances.

Thiele in his original article on conjugated double bonds sought to explain their properties by a theory of partial valence. The addition of two univalent atoms or groups to such a chain often took place at the carbon atoms 1 and 4, with the formation of a double bond between carbon atoms 2 and 3: $\overset{1}{C}=\overset{2}{C}-\overset{3}{C}=\overset{4}{C} \longrightarrow \underset{X}{C}-C=C-\underset{X}{C}$. Thiele postulated that in unsaturated compounds the whole of the affinity of the double bond is not employed, but that a part, called the residual affinity, remains free; it is in this free partial valence that the source of the addition capacity is found. He expressed the idea by the symbols, $C\overset{\vdots}{=}C$, $C\overset{\vdots}{=}O$, etc., in which the dotted lines denote partial valences. But in a conjugated system the central carbon atoms (*i. e.*, 2 and 3 above) appear to have lost a considerable part of their additive functions, for bromine adds first to the two end carbons. This is inconsistent with his scheme $C\overset{\vdots}{=}C-C\overset{\vdots}{=}C$, and a new form of double linking is produced, having no partial valences between carbon atoms 2 and 3, $C\overset{\vdots}{=}C-C\overset{\vdots}{=}C$. Thiele added, however, that after the extremes of a conjugated system exert their additive capabilities, the central carbon atoms become active, and their partial valences reappear as indicated, $\underset{X}{C}-\overset{\vdots}{C}=\overset{\vdots}{C}-\underset{X}{C}$.

As already stated, the literature on conjugated double bonds is so ex-

tensive, even after the field has been circumscribed as described above, that the material will have to be presented largely in the form of brief statements of reactions that are typical of those studied in each article to which reference is made. There will be room to place interpretations on only those reactions that are specially significant.

Hydrocarbons

Butadiene, $HC{=}C{-}C{=}CH$. The simplest hydrocarbon containing a conjugated system is butadiene. Hydrogen and bromine both add to the 1,4-carbons;[11] in the case of the addition of bromine, however, small quantities of the 1,2-isomer have been isolated.

Hexadiene, $HC{-}C{=}C{-}C{=}C{-}CH$ (H on the first and last carbons). Duden and Lemme[12] have shown that hexadiene adds bromine in the 1,4-position also.

Phenylbutadiene, $\emptyset C{=}C{-}C{=}CH$. This compound adds hydrogen to the 1,4-carbons.[13] Bromine, however, gives addition to the single double bond most removed from the phenyl group;[13] Riiber[14] found that hydrogen bromide gives addition at the same double bond: $\emptyset C{=}C{-}C{-}CH$ (Br H).

Diphenylbutadiene, $\emptyset C{=}C{-}C{=}C\emptyset$. Hydrogen gives 1,4 addition to diphenylbutadiene;[13] Thiele stated that bromine adds in a similar manner, but Straus[13] showed by the action of ozone on the bromine additive compound that the bromine atoms were attached to the 1,2-carbon atoms; if the bromine atoms were attached in the 1,4-position as postulated by Thiele, two molecules of bromophenylacetaldehyde, $\emptyset C{-}C{=}O$ (Br), would be formed on oxidation with ozone; Straus found the products of the oxidation to be dibromocinnamaldehyde and benzaldehyde; this forced him to the conclusion that 1,2-addition had taken place.

Wieland[15] presented more evidence in favor of Thiele's theory of 1,4-addition by showing that nitrogen peroxide adds to the end carbon atoms of the conjugated system in diphenylbutadiene and related compounds. Straus[13] explained this difference in the addition of bromine and the addition of hydrogen and nitrogen peroxide by assuming that hydrogen is added in the atomic form and that nitrogen peroxide when dissolved in organic solvents acts in the monomolecular form and, therefore, in both cases the substance to be added is present in the form in which it is added,

whereas in the case of bromine the addition is molecular. He concluded however, with the statement that no general rule can be formulated for the addition of halogens to conjugated linkages in the case of open chain hydrocarbons.

Aldehydes

Acrolein, $\overset{H}{}\overset{H}{}\overset{H}{}$ $HC{=}C{-}C{=}O$. Nascent hydrogen reduces acrolein to allyl alcohol.[16] Bromine gives 3,4-addition at the double-bonded carbon atoms[16] (in conjugated systems containing other atoms than carbon, the following numeration will be adhered to throughout: $\overset{4}{}\overset{3}{}\overset{2}{}\overset{1}{}$ $C{=}C{-}C{=}O$, and $\overset{4}{}\overset{3}{}\overset{2}{}\overset{1}{}$ $C{=}C{-}C{\equiv}N$). Hydrochloric acid yields β-chloropropionic acid.[16] Two molecules of sodium bisulfite will add to acrolein as follows:[17]

$$\overset{H}{}\overset{H}{}\overset{H}{}HC{=}C{-}C{=}O + 2NaHSO_3 \longrightarrow \overset{H}{}\overset{H}{}\overset{H}{}HC(SO_3Na){-}C(H){-}C(SO_3Na){-}OH.$$

When this product is warmed with alkali only one SO_3Na group is removed, leaving $\overset{H}{}\overset{H}{}\overset{H}{}HC(SO_3Na){-}C(H){-}C{=}O$. According to Sommelet[18] the introduction of an alkyl group on the α-carbon atom of acrolein prevents the reaction with two molecules of sodium bisulfite; he obtained only the normal addition product with α-alkyl acrolein.

Nef[19] obtained a 3,4-addition product with water on acrolein. The mechanism of the addition of water, hydrochloric acid, and sodium bisulfite to α,β-unsaturated aldehydes will be considered under the discussion of Kohler's work on cinnamaldehyde (see below).

Crotonaldehyde, $\overset{H}{}\overset{H}{}\overset{H}{}\overset{H}{}HC(H){-}C{=}C{-}C{=}O$. β-Chlorobutyraldehyde is produced by the action of hydrochloric acid on crotonaldehyde.[16] Haubner[20] found that crotonaldehyde reacts with sodium bisulfite just as acrolein does.

Cinnamaldehyde, $\overset{H}{}\overset{H}{}\overset{H}{}\phi C{=}C{-}C{=}O$. At the time Thiele set forth his explanation of addition reactions of conjugated double bonds the addition of sodium bisulfite to cinnamaldehyde was the only known case in which a substance with conjugated linkages was known to form more than one addition product with the same reagent. Thiele regarded this reaction as an exception to this theory, and was forced to conclude that "in some addition reactions the result is affected by influences that at present are indefinable." Subsequent research has shown that many substances

give more than one addition product to a conjugated system. Kohler[21] points out that the principal reaction between cinnamaldehyde and sodium bisulfite may be represented by the *reversible* equation:

$$\text{ØC(H)=C(H)—C(H)=O} + \text{NaHSO}_3 \rightleftarrows \text{ØC(H)=C(H)—C(H)(SO}_3\text{Na)—OH.}$$

A smaller quantity reacted by the non-reversible equation:

$$\text{ØC(H)=C(H)—C(H)=O} + \text{NaHSO}_3 \longrightarrow \text{ØC(H)(SO}_3\text{Na)—C(H)=C(H)—OH} \longrightarrow$$

$$\text{ØC(H)(SO}_3\text{Na)—C(H)—C(H)=O.}$$

Since, however, the first reaction was reversible and the second not, the "hydroxysulfonate" must pass slowly but completely into the saturated aldehyde. For this reason the latter was the only substance obtained when the reaction between equimolecular quantities of the reagents was allowed to run to completion. If the reaction was stopped before completion, a product of even a third reaction (owing to the rearrangement of the 1,4-addition product) was isolated:

$$\text{ØC(H)(SO}_3\text{Na)—C(H)—C(H)=O} + \text{NaHSO}_3 \rightleftarrows \text{ØC(H)(SO}_3\text{Na)—C(H)(SO}_3\text{Na)—C(H)—OH.}$$

But since this reaction was reversible like the first, the product ultimately disappeared when the reagents were present in equimolecular proportions. Thus Kohler was able to prove conclusively that one of the products of the reaction of sodium bisulfite on cinnamaldehyde is formed by 1,4-addition. It is more than probable that similar unstable intermediate products are produced in the addition reactions already noted of acrolein with water, hydrochloric acid, and sodium bisulfite, and in the addition of these same substances to crotonaldehyde. Throughout this article attention will be directed to those reactions in which it is likely that this mechanism best interprets what appears to be 3,4-addition.

Cinnamaldehyde adds hydrogen cyanide at the carbonyl group.[22] The addition of hydroxylamine likewise was found by Posner[23] to take place only at the 1,2-position; Posner in this same article points out the significant fact that conjugated systems containing only carbon atoms do not add addenda which consist of what he calls strongly positive components like hydrogen and the alkali metals, united to components of but slightly pronounced polarity, like NH_2, NHOH and CN; the addition reactions of hydrocarbons containing conjugated systems bear out this statement. On the other hand, conjugated systems containing an oxygen atom (or a nitrogen atom, as will be seen in the reactions of unsaturated nitriles) do add such substances in both the 1,2- and the 1,4-positions.

Nitriles

H H H
Croton Nitrile, HC—C=C—C≡N. Almost fifty years ago Claus[24]
H
showed that croton nitrile adds HCN at the 3,4-carbons.

H H
Cinnamic Nitrile, ØC=C—C≡N. Posner[23] discovered that hydroxylamine adds to cinnamic nitrile in a manner analogous to its addition to
H H
cinnamaldehyde, forming ØC=C—C=NH. Ethylmalonate gives an in-
NHOH
H H
teresting product with this same nitrile: ØC———————C—C≡N;
HC—$(COOC_2H_5)_2$ H
here also we probably have 1,4-addition as the first step.

H H H CN
Cinnamylidene-Malonic Nitrile, ØC=C—C=C——C≡N. An example of 5,6-addition to a conjugated system is found in the reaction of bromine with cinnamylidene-malonic nitrile.[25]

Acids

H H OH
Acrylic Acid, HC=C—C=O. Acrylic acid adds ammonia to give β-aminopropionic acid;[16] water and the halogen acids add similarly;[16] all three of these products are probably formed through 1,4-addition, followed by rearrangement to the 3,4-isomer. Hydrogen reduces acrylic acid to propionic acid, and bromine gives dibromopropionic acid.[16]

H CH_3 OH
α-Methylacrylic Acid, HC=C——C=O. Autenrieth and Pretzell[26] isolated the following product from the addition of aniline to α-methyl-
H CH_3 OH
acrylic acid: HC———C——C=O; here again we probably have 1,4-
ØNH H
addition as a preliminary step in the reaction.

H H H OH
Crotonic Acid, HC—C=C—C=O. One molecule of bromine or chlorine adds readily to the 3,4-carbons of crotonic acid.[16] β-Aminobutyric acid results from the addition of ammonia.[16] Hydrobromic acid adds similarly, the halogen atom going to the carbon most removed from the carboxyl group; the addition of hypochlorous and hypobromous acids, on the other hand, yields chiefly the α-halogen-β-hydroxy-butyric acid, although some β-halogen-α-hydroxybutyric acids have been isolated.[16]

Hydrazine and phenylhydrazine have been found to yield products similar to that formed by the action of ammonia.[16]

Cinnamic Acid. $\begin{matrix} & H & H & OH \\ \emptyset C & = & C & - C = O \end{matrix}$. Sodium amalgam reduces cinnamic acid to hydrocinnamic acid.[16] One molecule of bromine or chlorine adds also to the 3,4-carbons, while in the addition of hydrogen bromide and hydrogen iodide, the halogen atom attaches itself to the carbon atom most removed from the carboxyl group.[16] The production of phenyl-α-chlorolactic acid is to be expected by the addition of hypochlorous acid to cinnamic acid;[16] hypobromous acid gives a good yield of the corresponding bromoacid according to Riiber and Berner.[27]

Dimethylacrylic Acid, $\begin{matrix} & H & CH_3 & H & OH \\ HC & - & C & = & C - C = O \\ H & & & & \end{matrix}$. Prentice obtained two isomers when hypochlorous acid was added to dimethylacrylic acid, just as he showed that two isomers were formed in the same addition reaction of crotonic acid;[28] the chief product was the α-chloro-β-hydroxy acid, but a small amount of the other isomer was obtained. It should be emphasized here that data of a more quantitative nature than those available at the present time will have to be accumulated in order to formulate a completely satisfactory explanation of addition reactions of conjugated double bonds.

Sorbic Acid, $\begin{matrix} & H & H & H & H & H & OH \\ HC & - & C & = & C & - C = & C - C = O \\ H & & & & & & \end{matrix}$. Reduction of sorbic acid with sodium amalgam results in the hydrogen atoms attaching themselves to the 3,6-carbon atoms;[29] hydrogen has been found to add similarly to vinylacrylic, muconic, and piperic acids; the ease of reduction of such unsaturated acids is probably due to the formation of 1,6-addition products with the hydrogen, followed by rearrangement to the 3,6-isomers.

The addition of hydroxylamine to sorbic acid follows an unusual course:[30]

$$\begin{matrix} H & H & H & H & H & OH \\ HC & - & C & = & C - & C = O \\ H & & & & & \end{matrix} + 3NH_2OH \rightarrow \begin{matrix} H & H & H & H & H & OH \\ HC & - & C & = & C - & C - CNHOH \\ H & & & & NHOH & H \quad NHOH \end{matrix} + H_2O$$

Posner studied the addition of hydroxylamine to a number of unsaturated acids (*e. g.*, styrylacrylic, piperic, α-phenylstyrylacrylic and other α-alkylated unsaturated acids) and after several years he was able to draw some interesting conclusions: he states that hydroxylamine does not add to β-unsaturated acids, but that α-unsaturated acids, esters, anhydrides, amides, and hydroxamic acids do add hydroxylamine as in the above illustration with sorbic acid; he found the speed of this addition to be least with sorbic acid and greatest with α-alkylated acids.

H H H Ø OH

α-Phenylcinnamylacrylic Acid, ØC=C—C=C—C=O. Thiele in his original article on conjugated double bonds attempted to show that this acid absorbs bromine at the 3,6-carbon atoms, but Hinrichsen[25] proved that bromine added to the 5,6-carbons. Hinrichsen also showed that the paranitrophenyl derivative of this acid gave 5,6-addition of bromine,

H H H ØNO OH

yielding ØC——C——C=C———C=O. α-Cyancinnamylacrylic acid

Br Br

gave 5,6-addition similarly with bromine.[31]

H H H COOH OH

Cinnamylidenemalonic Acid, ØC=C—C=C————C=O. Riiber[14] obtained the following 3,4-addition product with HBr:

H H H COOH OH

ØC=C—C——C————C=O. Hinrichsen stated that he isolated

Br H

similar 3,4-addition products with HCN and sodium alcoholate; Macleod[32] contended that the reaction consisted primarily in 1,4-addition to the system C=C—C=O, the hydrogen going to the oxygen of the carbonyl group, from which it subsequently shifted to the 3-carbon atom.

OH

H H C=O H

Dibenzalpropionic Acid, ØC=C—C===CØ. This acid contains a system of crossed double bonds, and which of the two conjugated systems, C=C—C=C or C=C—C=O, takes part in an addition reaction depends largely upon the reagent added. Bromine adds to the system of all carbon atoms, since bromine has a greater affinity for carbon than for oxygen; the main product of the reaction is the 1,4-product,

OH

H H C=O H

ØC—C=C———CØ; there is some 3,4-addition also, for a secondary

Br Br

OH

H H C=O H

product has been isolated: ØC—C—C===CØ. Hydrogen and hydrogen

Br Br

bromide, however, add to the system C=C—C=O, since the affinity of hydrogen for oxygen is greater than that of hydrogen for carbon;[33] the compound formed by the addition of hydrogen has the structure:

OH

H H C=O H

ØC=C—C———CØ.

H H

HO H H H H OH

Muconic Acid, O=C—C=C—C=C—C=O. Baeyer[34] has shown that the ease of reduction of unsaturated acids depends upon the proximity of the double bond to the carbonyl group; the reduction product of

HO H H H H OH

muconic acid is, O=C—C—C=C—C—CO. Baeyer and Rupe[34]

H H

obtained similar addition products by the action of bromine on muconic acid.

Esters

H H H H OCH_3

Methyl Styrylacrylic Ester, ØC=C—C=C—C=O. The addition reactions of this ester were early pointed out by Hinrichsen[25] as exceptions to Thiele's rule of 1,4-addition. Bromine adds to the carbons in the 3,4-position; hydrogen bromide gives an addition product at the same double bond, the bromine atom attaching itself to the 4-carbon; sodium ethoxide in ethereal solution adds similarly. These reactions are very likely exceptions to Thiele's rule of 1,4-addition only in that the 1,4-addition products are unstable and rearrange to the 3,4-isomers.

The work of Posner on the addition of hydroxylamine to unsaturated acids has already been discussed; this same worker discovered that Riedel and Schulz[35] were mistaken in thinking that the addition product of hydroxylamine on the ester of styrylacrylic acid has the formula,

H H H H OH

ØC=C—C————C—C=NOH, NH_2OH; Posner proved the struc-

NHOH H

H H H H OH

ture to be: ØC=C—C————C—C—NHOH.

NHOH H NHOH

H H H CN OC_2H_5

Ethyl α-Cyan Styrylacrylic Ester, ØC=C—C=C——C=O. According to Hinrichsen,[36] this ester gives 5,6-addition of bromine.

H H H $COOCH_3$ OCH_3

Methyl Cinnamylidenemalonate, ØC=C—C=C————C=O. This ester also gives a 5,6-addition product with bromine.[36] Hydrogen cyanide gives 3,4-addition to both methyl and ethyl cinnamylidenemalonate, the cyanide radical attaching itself to the 4-carbon;[4] this reaction, together with the addition of potassium acid sulfite to these esters, were exceptions that Thiele himself found to his rule of 1,4-addition.

Ketones

H H R

Ethylene Ketones, HC=C—C=O. Maire[37] has shown that ketones of

this type give 3,4-addition of hydrogen bromide, the bromine atom attaching itself to the 4-carbon. Maire and Blaise[38] obtained the following addition product with hydroxylamine, $HC(H)(NHOH)-C(H)-C(R)=NOH$; β,γ-unsaturated ketones add only one molecule of hydroxylamine.

Benzal Acetone, $\emptyset C(H)=C(H)-C(CH_3)=O$. Posner[39] isolated two products from the action of ethyl mercaptan upon benzal acetone; with one mole of mercaptan he obtained a 3,4-isomer, $\emptyset C(H)(SC_2H_5)-C(H)-C(CH_3)=O$, which he stated was formed from the rearrangement of the 1,4-isomer. Two moles of the mercaptan reacted as follows:

$$\emptyset C(H)=C(H)-C(CH_3)=O + 2C_2H_5SH \longrightarrow \emptyset C(H)=C(H)-C(S-C_2H_5)(S-C_2H_5)-CH_3 + H_2O.$$

Posner attempted to draw the conclusion that all the facts of 1,2- and 1,4-addition could be explained by the variable activity of the carbonyl group; in his own words: "The more completely the hydrogen atoms in combination with the carbon atoms that participate in the double linkage or that adjoin the carbonyl group are replaced by hydrocarbon residues, the less the tendency of carbonyl to condense with mercaptans and the more favorable the conditions for the formation of monomercaptans."

The reduction of benzal acetone is significant: the addition of hydrogen to such an α,β-unsaturated ketone does not follow the rule of reduction of the carbonyl group to CHOH, as we would expect without the aid of Thiele's theory; instead, the conjugated system is so active at the 1,4-positions that hydrogen attaches there, and then this product rearranges to the 3,4-isomer. Harries[40] has made use of the same mechanism of 1,4-addition to explain why the reduction of such ketones often results in the interaction of two molecules, the condensation always taking place in the β-position, never the α-position to the carbonyl.

Benzalacetophenone, $\emptyset C(H)=C(H)-C(\emptyset)=O$. Kohler[41] has studied the addition of nitro-paraffins and sodium nitro-paraffins to α,β-unsaturated ketones. He isolated the following stable 3,4-addition product by the action of nitromethane on benzalacetophenone, $\emptyset C(H)(CH_2NO_2)-C(H)-C(\emptyset)=O$. In the addition of the sodium nitro-paraffins, the metal attaches to the oxygen and the remainder of the molecule goes to the carbon in the 4-position; this

mechanism is the same as Kohler uses to interpret the action of Grignard's reagent on compounds containing conjugated bonds.

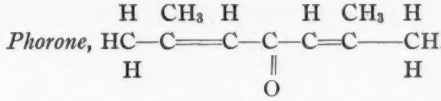
Mesityl Oxide, $HC(H)-C(CH_3)=C(H)-C(CH_3)=O$. Mesityl oxide adds two atoms of bromine in the 3,4-position.[16] Lapworth[42] isolated an addition product at this same double bond with hydrogen cyanide; the cyanide radical was attached to the 4-carbon. Pinner[43] obtained an analogous product with sodium acid sulfite, and Sokoloff[44] showed that the reaction of mesityl oxide and strong ammonium hydroxide followed the same course.

Benzoylacrylic Acid, $O=C(\emptyset)-C(H)=C(H)-C(OH)=O$. Bougault[45] separated the following interesting addition product from the action of aniline on benzoylacrylic acid, $O=C(\emptyset)-C(NH\emptyset)(H)-C(H)(OH)-C=O$; assuming the formation of an intermediate 1,4-addition compound, we must conclude that it is the C=O group of the acid, and not of the ketone, that is involved.

Distyryl Ketone, $\emptyset C(H)=C(H)-C(=O)-C(H)=C(H)\emptyset$. Borsche[46] extended Thiele's theory to the conjugated systems of the type $C=C-C(=O)-C=C$. He states that since there are three outer atoms on which the residual affinities can collect, the reactivity should be greater than for a system containing two unsaturated groups; furthermore, the oxygen atom should have a greater amount of residual affinity than the end carbon atoms, since the central carbon atom to which it is attached uses more of its affinity in neutralizing the affinities of each of the adjacent carbon atoms. Such he found to be the case in his experiments on di-α-β-unsaturated ketones of the type of distyryl ketone; Borsche found that this ketone is easily reduced by four atoms of hydrogen to the saturated ketone. When, however, there is more than one double bond on each side of the carbonyl group, the reduction proceeds with difficulty, and resins are often formed.

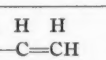
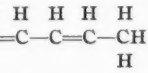
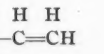
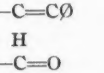
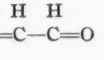
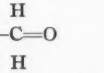
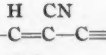
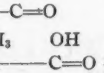
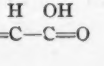
By the addition of phosphorous pentachloride to distyryl ketone Straus[47] obtained a chloride, the structure of which remained undetermined for some time; finally he established it to be, $\emptyset C(H)=C(H)-C(Cl)=C(H)-C(Cl)\emptyset$, but he added that there was perhaps also some 1,2-addition such as was found by Kohler for Grignard's compounds. Straus pointed out that the unsym-

metrical structure of the chloride explained why only one chlorine atom took part in its reactions, and that the two double bonded carbon groups do not behave alike in the addition of halogens.

Phorone,  Posner[48] obtained a saturated ketone by the addition of two molecules of ethyl mercaptan to phorone; the SC_2H_5 groups attached themselves to the carbons most removed from the ketone group.

Summary

TYPES OF ADDITION PRODUCTS OBTAINED

Compounds	Addenda										
	H_2	Cl_2 Br_2	$NaHSO_3$ $KHSO_3$	HOH ROH RONa RSH	HCN	HCl HBr	HOCl HOBr	NH_3 $ØNH_2$	NH_2OH
	1,4	1,4							
		1,4							
	1,4	3,4				3,4			
	1,4	1,2							
	1,2	3,4	3,4	3,4		3,4			
			3,4			3,4			
			3,4		1,2				1,2
					3,4				
									1,2
		5,6							
	3,4	3,4		3,4		3,4		3,4	
								3,4	
		3,4				3,4	3,4	3,4	

TYPES OF ADDITION PRODUCTS OBTAINED (*Continued*)

Compounds	Addenda									
	H_2	Cl_2 Br_2	$NaHSO_3$ $KHSO_3$	HOH ROH RONa RSH	HCN	HCl HBr	HOCl HOBr	NH_3 ϕNH_3	NH_2OH
H H OH ØC═C—C═O	3,4	3,4				3,4	3,4		
H CH_3 H OH HC—C═══C—C═O H							3,4		
H H H H H OH HC—C═C—C═C—C═O H	3,6								
H H H Ø OH ØC═C—C═C—C═O	3,6	5,6							
H H H COOH OH ØC═C—C═C———C═O				3,4	3,4	3,4			
H H COOH H ØC═C—C═══CØ	3,4	1,4 3,4				3,4			
OH H H H H OH O═C——C═C—C═C—C═O	3,6	3,6							
H H H H OCH_3 ØC═C—C═C—C═O		3,4		3,4		3,4			
H H H Ø OCH_3 ØC═C—C═C—C═O		5,6							
H H H $COOCH_3$ OCH_3 ØC═C—C═C———C═O		5,6	3,4		3,4				
H H CH_3 ØC═C—C═O	3,4			3,4					
H CH_3 H CH_3 HC—C═══C—C═O H		3,4	3,4		3,4			3,4	
H H H H ØC═C—C—C═CØ ‖ O	3,4								

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Hypodermic Injection Cures Plant Sickness. Manganese deficiency, a disease afflicting plants that grow in certain types of soils, can be cured by hypodermic injections with a solution of this necessary mineral, as well as by the more usual method of supplying fertilizers containing it. Dr. Forman T. McLean, of the Rhode Island Agricultural Experiment Station, recently told a *Science Service* representative of his experiments. He raised a number of plants on soil with all the natural manganese removed, and when they began to show the characteristic symptoms of manganese starvation he injected into their leaves a very weak solution of a salt containing it. The sick plants very promptly recovered.—*Science Service*

APPLICATION OF CHEMISTRY TO THE TEACHING OF BIOLOGY

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This paper is not intended to review all the important applications of chemistry which one is likely to encounter in teaching a course in general biology, nor does it make any attempt to discuss newly discovered principles. It is directed primarily to busy teachers of high-school biology who, for want of suitable material, frequently find it difficult to maintain the interest of the class or may even fail to convey to the pupils a very clear conception of certain difficult phases of the subject. While most biology teachers have had courses in chemistry, it is probable that in only a relatively small proportion of these courses has the biochemical phase of the subject been stressed. If this paper will serve to suggest a few helpful methods, and possibly hint at a clue to more extended work in this branch of the science, it will have achieved its purpose.

During the discussion of the various classes of foods some instructors include tests for the several classes. Probably the most frequently used protein test in biology courses is the xanthoproteic reaction. Numerous texts and manuals which included only one test for proteins choose this reaction. It is a rather common belief that *all* proteins respond to this test and that all non-protein material gives negative results. A number of books on the market either insinuate as much or distinctly state that such is the case. This reaction really depends upon the presence of the benzene nucleus and consequently proteins which do not contain tyrosine, phenylalanine, or tryptophane will not give a positive xanthoproteic test. On the other hand, non-protein material such as phenol and other compounds containing a benzene ring, will give a positive test. (See A. P. Mathews, Physiological Chemistry.)

It is true, however, that *most* proteins give a positive xanthoproteic test, and since it can be conveniently applied to both solids and liquids, there is no doubt that the test can be employed to advantage on some occasions. The procedure consists in adding 1 cc. of concentrated nitric acid to a small amount of the solid or dissolved sample, and heating for two or three minutes, whereupon a lemon yellow color develops if certain proteins are present. If, after cooling, a small amount of ammonium hydroxide is added the color will be changed from lemon yellow to orange. Incidentally, the xanthoproteic test is performed whenever nitric acid and ammonium hydroxide are accidentally dropped on one's hands.

One of the important properties of proteins which can always be relied upon to attract the interest of the students and at the same time help to fix in their minds at least one useful fact is their precipitation by means of the heavy metals. Probably every high-school student can recall having seen poison labels which stated that the white of an egg could be given as

an antidote. The reason for the efficiency of this antidote can readily be demonstrated by setting up test tubes containing a few cubic centimeters of egg albumin solution, and then adding several drops of solutions of such common poisons as lead acetate, mercuric chloride, and lead copper sulfate.

Fehling's test for reducing sugars is too well known to require the procedure to be given here, but a word concerning the precipitate of copper oxide may be in order. To satisfy his curiosity the author recently consulted a half score of textbooks and laboratory manuals, and found that these books expressed a half-dozen different opinions regarding the color of the precipitate obtained in the presence of glucose. Here they are; red, bright red, brick red, yellowish red, reddish brown, and yellow brown. Each is correct, to a limited extent. According to Fischer and Hooker[1] the color of the precipitate may range from the green bands of the spectrum over to the red end. It all depends upon how finely the precipitate is divided. If a red precipitate is desired it can be obtained by having the sugar solution sufficiently dilute. With a rather concentrated solution the glucose attacks the cupric hydrate at many more points than would be the case if only a comparatively small amount of sugar were present. The result is that the cupric hydrate is exhausted while the particles of cuprous oxide are still quite small, in which case a green to yellow precipitate is formed.

Quite early during the study of plants it is customary to emphasize the importance of chlorophyll, but as a rule no attempt is made to give the student an opportunity to see a specimen of the isolated pigment. It is not well to ask the student to accept too many things on faith. A small quantity of chlorophyll, either as a solid or in solution, may be a considerable help in enlisting the interest of the class, and it can be prepared by the instructor if he is willing to sacrifice some of his time for this purpose.

Almost any kind of dried leaves will serve as a source of chlorophyll. Leaves of stinging nettles, celery, dandelion, or even lawn grass[2] will be satisfactory. A suction flask provided with a Büchner funnel comprises the apparatus required for the extraction of the pigment from the leaves. Ten grams of powdered leaves are put on a filter paper in the Büchner funnel and, after having drawn the powder against the filter by means of suction, 10–12 cc. of 80% acetone is added. After being allowed to soak into the powder for several minutes the acetone is drawn off by applying suction. The leaf powder is similarly treated with successive portions of 80% acetone until 100 cc. have been drawn through. This acetone extract contains, in addition to chlorophyll *a* and chlorophyll *b*, the yellow pigments carotin and xanthophyll. If desired, the acetone can be re-

[1] Martin H. Fischer and Marian O. Hooker, *J. Lab. and Clin. Medicine*, **3**, 368 (1918).

[2] In the case of grass, the fresh material should be used.

moved by evaporation on a steam bath (under a hood) and a dark green amorphous mass will be obtained.

In order to separate the chlorophyll from the yellow pigments the following procedure is employed. The acetone extract is poured into twice its volume of petrol ether contained in a separatory funnel, and an equal volume of distilled water is added by pouring slowly down the sides of the funnel—too much agitation may cause an emulsion to form. After the ethereal layer has risen to the surface the lower layer is drawn off. This washing by the addition of distilled water and the subsequent removal of the aqueous layer should be repeated three or four times to remove the acetone. One hundred cc. of the ethereal pigment solution is shaken with 40 cc. of methyl alcoholic potash—made by dissolving 30 g. KOH in 100 cc. methyl alcohol. After the reappearance of the green color slowly add 200 cc. of water and a little more ether. After being shaken two distinct layers separate, the lower one containing chlorophyll *a* and chlorophyll *b*, and the other containing the yellow pigments. The chlorophyll is present as the potassium salt, which may be obtained as a solid by drawing off the lower aqueous layer and evaporating on a steam bath, or distilling off the water under diminished pressure.

While studying digestion one of the first things the student is told is that the saliva effects the transformation of starch into a soluble sugar. This can be demonstrated experimentally without the use of much apparatus. One of the materials required, of course, is saliva. This is obtained by chewing paraffin to increase the flow, and then filtering the saliva through ordinary filter paper in order to remove skin cells and other solids which may have been present in the mouth. While collecting the saliva—which filters rather slowly—some mucilage can be prepared. About one gram of starch is stirred up in 20 cc. of distilled water, poured into a beaker containing 80 cc. of boiling water, and boiled for a quarter of an hour. The starch mucilage is shown to be free from reducing sugars by testing a portion with Fehling's solution. To study the action of the saliva 10 cc. are mixed with 50 cc. of the starch mucilage—after it has become cool—and from time to time a few drops are removed to be tested for starch. Before being completely transformed into maltose, the starch, in successive stages, is changed into soluble starch, erythrodextrin, various achroodextrins, and finally maltose. After the starch mucilage has lost its opalescent appearance it has been changed into soluble starch. As long as a blue color is formed with iodine solution, starch is present; when the mucilage produces a red color with iodine, the erythrodextrin stage has been reached, and after no color results when tested with iodine, digestion has arrived at the achroodextrin stage or beyond. The presence of maltose can be detected by means of Fehling's solution.

Most students in elementary biology courses are obliged to restrict

their ideas regarding the circulation of the blood and the existence of blood corpuscles to whatever they can derive from the explanations given in some textbook, supplemented by further elucidation on the part of the instructor. With a microscope available, a demonstration of the white corpuscles of the blood actually circulating through the blood-vessels of an animal becomes a matter of relative ease and negligible cost. Probably the most suitable animal for this experiment is a small fish. (Small goldfish are frequently on sale in the 5 and 10 cent stores.) By stirring into the aquarium a solution of chloretone, the fish can be anesthetized, after which it can be laid on the microscope stage. The tail end is placed under the objective, and after the instrument has been properly focused the white blood corpuscles can be seen in circulation. The fish may live for about twenty minutes after being anesthetized, thus allowing ample time for a fair-sized class to observe the phenomenon.

Those who desire to find additional material which can be adapted to biology courses will no doubt find suggestions in books on physiological chemistry by Mathews, Hawk, Pettibone, and others.

Poison Ivy Remedies Simple and Effective. Victims of poison ivy, poison oak, and poison sumac can end their trouble very easily, according to James F. Couch, of the U. S. Department of Agriculture.

"Just ask your druggist to make up a five per cent solution of potassium permanganate," he says, "and swab it on the poisoned places with a bit of absorbent cotton or a soft cloth. The permanganate destroys the ivy poison but does no harm to the skin, except that it makes a brown stain. Most of us do not want to let this remain; and it can be removed by washing with a one per cent solution of oxalic acid. Oxalic acid is a poison, so that if you are afraid of children getting hold of it, you may use instead a one per cent solution of sodium bisulfite, or even just plain soap and water, though the latter is a bit slow in taking off the stain. If the skin has been very much broken by scratching or otherwise and is raw, the oxalic acid will cause a temporary stinging and soap and water is preferable for removing stains from such sensitive surfaces. If the skin is very tender the solution of potassium permanganate may be diluted with water before using."

The permanganate treatment is recommended only as a remedy for poisoning that has already taken place. Persons who know that they are likely to be poisoned may prevent the plants from harming them with a wash devised by Dr. James B. McNair of the Field Museum, Chicago. This consists of a five per cent solution of ferric chloride in a fifty-fifty mixture of water and glycerin. This is to be washed on all exposed parts of the skin and allowed to dry there, before going where the dangerous weeds grow. The iron in the chemical combines with the poisonous principle of the ivy and changes it into a harmless, non-poisonous compound.

None of the remedies recommended by the two scientists have any patent or proprietary medicines in them. They are standard and well-known chemicals, and any druggist can make them up in a few minutes.—*Science Service*

HOW GRADE LABORATORY NOTEBOOKS?

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This subject has to do with a part of the work of a teacher in chemistry that has in many cases proved to be a most irksome and ever-to-be-faced bore. Personally, I am free to admit that, at times, I have found it to be so.

However, with the system which I am using at present, most of the boredom has been eliminated. In this brief paper I shall simply describe my own methods concerning the grading of laboratory notebooks. They are methods which I have found to be the most efficient in my own experience, and which I have followed consistently for four years. Briefly, here they are:

The student has a bound notebook of sufficient size to contain write-ups of all the experiments performed in the laboratory during the year. In it he records the data obtained from each experiment, together with equations and all necessary explanations, making the write-up as brief as possible, still including the essential points involved. Each experiment is written up at some time during the same laboratory period in which it was performed. Each student in the section brings his notebook to the instructor once during the period for an O.K. The instructor goes over the exercise or exercises (in the student's presence), thoroughly quizzing him, if necessary, on points in which he is evidently weak, and calling his attention to any details which have been omitted. Any necessary minor corrections are made then and there. If erroneous or inaccurate results are presented, he is sent back to repeat the work and to report again later. Each completed exercise which has been passed upon favorably is rubber-stamped (date accepted) by the instructor.

In brief, then, the notebook is looked over, not in the office a week or more later, but right in the laboratory, at elbows with the student, and during the same hour in which he has performed the exercises and written them up. No grade is placed on these exercises from period to period. To be sure, an estimate is placed on the notebook at the end of the semester. But the student's ability to absorb ideas, to reason and to interpret, his general laboratory technic, and his personal attitude toward his work, all are factors which figure significantly in his laboratory grade.

It is true that, in the above system, the student spends considerable laboratory time in writing up experiments. However, he is expected to have his experiments well in mind before he comes to the laboratory. He is frequently quizzed and coached on them at the beginning of the period. And he is expected, furthermore, to plan his work in such a way as to make most efficient disposal of his time. And since he makes brief and concise write-ups while the material is fresh in mind, it is to be doubted

whether the extra experiments that might be done in this time would be more valuable to him.

It is also true that the instructor spends considerable laboratory time in going over these notebooks. But this time practically coincides with the time that he, by a series of leading questions, gets the student to see where he made his mistakes, how to interpret his results, and see their significance. It is on these occasions that he can do his most intensive teaching and can be of greatest individual help to the student. It is then that he comes to know him most intimately, and can find out accurately just how much chemistry he knows; for he does not hesitate to quiz him unmercifully if it appears to be necessary. It has been my experience that, for a section of twenty students, the time spent in going over these exercises during the period does not materially interfere with general supervision of the laboratory work. I believe that it is time well spent.

There are experiments of quantitative nature during the year which are longer and involve more theory and calculations than the average. Three or four such experiments are usually included during the year. For these, the student submits data to be O.K.'d in the usual manner. In addition, one week later, he turns in a full formal report including full description of apparatus used, the procedure, general theory involved, discussion of results and sources of error, and answers to collateral problems and questions. Here the student who likes to write up his experiments at home and in an elaborate way gets his heart's desire. These reports are written up and graded outside of laboratory hours.

It must be admitted that any given method concerning the treatment of laboratory notebooks has its talking points and also its objections. There is not sufficient time to discuss them here. For my own part, the most pertinent question to be asked is, "How does it actually work out?" And here the personality of the instructor enters in. No two have identical ideas, and no two can be expected to conduct a laboratory section in chemistry in exactly the same manner.

Personally, I have found that grading laboratory exercises outside of laboratory hours, doing it twice a week or once a month, thoroughly and painstakingly or hastily picking out mistakes at random and slapping down a grade largely based on general impressions, was an endless drudgery. It was a part of the work of instruction that I would cheerfully shove off onto the shoulders of a budding assistant if one happened to be available. Whereas, by going over the exercises with the student immediately after he has performed and written them up, the task becomes not a bore, but an absorbing interest and pleasure in getting him to see his mistakes and to profit by them.

HOW, WHEN, AND WHERE GRADE LABORATORY NOTEBOOKS?*

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HOW?—Assuming that we are all agreed on the fundamental purposes and functions of the laboratory notebooks, we may at once proceed to ascertain how we may best realize these aims and purposes in our current educational practice. There can be no doubt that the grading of notebooks is of the utmost importance. To require a written record of a student's laboratory experiences and then not to evaluate the result is the unpardonable sin of the lazy teacher. So, granting the imperative need for a proper grading of notebooks, we may well inquire into the best method of grading them, as well as to the most expedient time and place for so doing. In our inquiry into the grading of this major phase of our science teaching, we are ever mindful of the ends to be achieved. We must have in mind a definite ideal, an attainable standard, as a part of which a written record of an observed phenomenon may well be expected to articulate. To particularize on this point, let not any science teacher think but that a student's laboratory technic, ideals, and attitudes will be faithfully reflected in his written record and in his drawings, and frequently will find expression in his reaction to related situations out in life experiences. Herein lies the teacher's opportunity to mold character and to build for the future. Thus we find in the grading of notebooks almost a divine imperative, "to grade note books properly and conscientiously" and thereby:

(1) Inspire love of truth, not half truths, which foster dishonesty of thought and action.

(2) Compel pupils to think well.

(3) Stimulate a desire to know and understand, through:

- (*a*) keen observation,
- (*b*) careful analysis and correlation,
- (*c*) wise judgments and deductions,
- (*d*) definitely organized self-expression in a notebook.

And yet this ideal must be a flexible and progressive standard. A notebook representing the record of a series of laboratory performances of ten years ago, no matter how well performed, or how well recorded, should not today be acceptable as a first-class response. We are making epochal history in the realm of science in these days. Ten years makes ancient history of our science textbooks, and unless we as teachers of science keep pace with modern scientific progress we must not complain when our students classify us with the fossils of the carboniferous era. Grade

* Paper delivered at a meeting of the Illinois Association of Chemistry Teachers, Nov. 19, 1926.

notebooks, then, in the light of what the boy and girl of 1926 knows, as a matter of course, without any undue emphasis on pure theory, ancient or modern. Expect much from the boy and girl, and let them know you are depending on them for great things. Then check up on them. But when?

WHEN?—Every day! If notebooks are graded daily, right habits of laboratory practice, thinking, and recording can be fostered. The line of least resistance always leads down. We must know what our boys and girls are thinking. Are they "stalling?" Are they doing just enough to "get by?" Or are they honest and conscientious? The notebook will tell, and the teacher should know daily. Is the student in the lower part of the curve losing hope and about ready to give up trying because there was something he didn't understand? The notebook will reflect this condition. Is the teacher losing his grip on the confidence of his pupils? Where better regain it than through the notebooks, and this cannot be done if the grading of the notebooks is sporadic and uncertain.

WHERE?—The old saying "strike when the iron is hot" may well be written "grade while the ink is wet." It is of very little value to a student to see red ink over an exercise which he has forgotten all about and has lost interest in. There may be some arguments against grading notebooks during the laboratory period but the advantages far outweigh these. The student is working; his interest is at a high pitch; and the teacher is in the background. From there he controls the situation, recreates and vitalizes natural phenomena until the student thrills with understanding and responds with normal self-expression. Shall the teacher retire at this point and wait until the enthusiasm has died out before accepting or rejecting the student's response? Why not grade his notebook then and there and give him the benefit of a fresh opportunity to correct his error? Is it likely that the electrons of youthful understanding and enthusiasm will continue to flow after the warming incandescence of the teacher's interest has been turned off, until such time as he shall again see fit to act on the merits of their efforts? Obviously such a policy invites distrust, carelessness, and dishonesty in the student and negatives any positive good that might otherwise be achieved through the use of notebooks.

"Alchemist" Tests Fail. If ordinary lead was changed into mercury and the rarer element thallium by two Dutch experimenters over a year ago repetitions of the process have not been successful.

In a communication to the English scientific magazine *Nature*, Dr. L. Thomasen, of the Norman Bridge Physics Laboratory of the California Institute of Technology, states that he has tried to transmute the elements by the same method. More powerful electric currents were employed than those used by Smits and K'arssen, the Dutch scientists. But Dr. Thomasen obtained no evidence of the slightest trace of thallium or mercury having been formed from lead.—*Science Service*

A NOTE ON THE RESULTS OBTAINED FROM IOWA CHEMISTRY TESTS

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In an earlier publication Cornog and Stoddard[1] present results of the use of their tests in various colleges throughout the country. Two conclusions in their paper appear to be open to question, and require some notice.

Part I. Variability in Aptitude

In Table IV they show mean scores from different colleges in the Aptitude Test. In discussing this table they say, "A noticeable feature of this table is the rather narrow limits within which the mean scores fluctuate. East, west, country or city, large institution or small, the student in the middle of the class most often makes a score not varying widely from 60. This indicates that freshman chemical aptitude is much the same everywhere, and that no college represented has a notable initial handicap or advantage in the quality of its starting material." In Table V they give corresponding figures for the Training Test, and discuss the wide range of mean scores there shown. They conclude "there are small differences in the average ability of freshmen to learn chemistry, but great differences in the capacity of different high schools to teach chemistry."

An examination of their tables does not seem to warrant such a statement. For purposes of just comparison the mean scores of colleges presenting results of both tests have been isolated. (The finding discussed below holds if all colleges in both tables are taken, but the selected comparison is more valid.)

College	Aptitude Test Mean score	Training Test Mean score
Case School of Applied Science	73.74	89.28
Earlham College	52.66	63.20
Greensboro College	34.88	31.50
University of Iowa	47.46	54.73
Kansas Agricultural College	59.78	44.39
University of Minnesota	67.42	65.45
Montana State College	64.48	47.05
University of North Carolina	63.00	66.50
Rutgers University	77.31	90.32
Santa Barbara	69.38	70.13
Utah Agricultural College	44.92	67.15
University of Washington	70.28	69.71
Possible Score	(115)	(188)

The ranges of these means are, for:

Aptitude Test, from 34.88 to 77.31 (diff. 42.42)
Training Test, from 31.50 to 90.32 (diff. 58.82)

[1] THIS JOURNAL, 3, 1408–15 (Dec., 1926).

Thus the Aptitude Test scores show a narrower range of variation. But the possible scores, which give an indication of the range within which the mean scores can vary, are not the same, and the raw comparison is not admissible. It may be said that when the possible range as indicated by the possible score equals 115, the actual range of mean scores equals 42.43, and when it equals 188, the actual range of mean scores equals 58.82. For each test, the only legitimate comparison of variability is the ratio, *range/possible range*. This ratio is in the case of the

Aptitude Test	0.369
Training Test	0.314

Thus the true variability of the Aptitude Test scores is actually greater than that of the Training Test. The difference, however, is small and may be neglected. It may be said, then, that Cornog and Stoddard's tables show that the differences in aptitude of students is just as large as are the differences in ability, when this aptitude is trained.

Furthermore, if the correlation between the rank orders of the colleges, on the basis of the two tests, is calculated it is found to be 0.78. That is to say, a college which receives well-trained students in chemistry also receives untrained students with a high degree of chemical aptitude. What this indicates as to the "capacity of different high schools to teach chemistry" is left to the speculative insight of the reader of this note.

Part II. The Kind of Chemistry That Is Retained by Freshmen

In Part III of their paper, Cornog and Stoddard give figures illustrating, and discuss, "how much and what kind of chemistry is retained by freshmen who have had high-school chemistry." On p. 1414 they show the percentage of students answering certain specific questions, and use these cases in drastically criticizing high-school chemistry teaching, and the aptitude of students.

In the Glenn and Welton tests, certain questions were deliberately included more than once, usually in different tests. The tests, numbering some 36 on various topics, are supposed to have been taken at an interval of about a week, in sequence. The following results of these duplicated items are illuminating.[2]

No. of test	Test question	No. of item in test	Percentage correct
12	Complete NaOH + HCl =	8	85
14	Complete NaOH + HCl =	39	78
14	Name an acid used by plumbers	40	60
15	Name an acid used by plumbers	38	32
12	The formula for ammonium hydroxide is ?	5	70
12	The formula for ammonium hydroxide is ?	37	60

[2] These results were isolated from unpublished (but shortly to be published) figures prepared by Mr. Glenn.

The percentage of pupils correctly answering a given question seems to depend not only on their absolute ability to do so, but partly upon the general setting and partly upon the position of the question in that setting.

In general, test results show that the later an item is placed in a test the smaller is the percentage of children correctly answering it.[3] The reason usually given for this is that tests are built so that questions become more difficult toward the end. This may be one reason, but the illustrative cases given above show that other factors operate; for 70% of pupils knew the formula for ammonium hydroxide when placed early in a test, but only 60% knew it 15 minutes later, when they were near the end of the same test. It would appear that, even if ample time is given, some children do not get through so far as to attempt some questions which they can answer. This must have happened to 10% of the children who took Glenn's test No. 12.

These results illustrate the point made, namely, that one cannot justly say that a certain percentage of children cannot answer a particular question without stating the conditions under which that question was given. The fact that 31% of students fail to complete and balance the equation KOH + HCl = in a specific circumstance (in the Iowa Test) does not warrant the general assumption that "about a third of the group learned nothing of equation writing while in high school."

Conclusion

Criticisms of present results and practice in the teaching of high-school chemistry are becoming increasingly numerous. Test methods and statistical treatment of results are increasingly used as means for obtaining grounds for criticism. The above analysis of presented results of such usage appears timely at this stage, for if testing procedures are not to defeat their own ends and fall into disrepute, they must be rigidly exact and scrupulously fair to present teachers and students.

[3] Mr. Glenn's figures show this very definitely. See Stoddard's figures in University of Iowa Studies in Education, Vol. III, No. 2, pp. 44–52.

Corn Uses Nitrogen Captured by Bacteria. Will corn come to rival clover as a nitrogen-catching crop? The activity of the helpful bacteria that live in the little lumps or nodules on clover and pea and alfalfa roots has long been known. Now, at the meeting of the First International Soil Science Congress held recently, Dr. Georges Truffaut and Dr. N. Bezssonoff, of Versailles, France, advanced data which tend to prove that other plants, without definite root nodules, are able to feed soil bacteria, which in their turn capture nitrogen from the air and so benefit their benefactors. The two experimenters stated that they were unable to grow ordinary corn in white sand from which every trace of nitrogen had been chemically removed, and to which no nitrogenous fertilizers were added. They are of the opinion that the corn roots supply some kind of needed food material to the bacteria on which the latter can live while they work at their business of capturing nitrogen from the air.—*Science Service*

HIGH-SCHOOL SCIENCE SURVEY OF SOUTH DAKOTA*

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This study was undertaken with the purpose of determining the status and present tendencies of high-school science teaching in South Dakota, with a view to formulating certain suggestions indicating how science teaching in this state might be placed upon a more rational basis than that upon which it is conducted at present.

The data for this study were compiled from the fifteenth, sixteenth, and seventeenth Biennial Reports of the Superintendent of Public Instruction,[1]† Directories of Secondary Schools and Educational Institutions of South Dakota for the years 1917–18 to 1924–25, inclusive, and from a science survey questionnaire sent out by the writer in the fall of 1924 and 1925.

Predominance of Small High Schools

In order to facilitate a fuller appreciation of our science teaching problems it may be well to note that in 1925–26[1] there were 435 high schools of which 267 were four-year accredited by the state department of education and 57 were accredited by the North Central Association. Ninety-six per cent of these four-year accredited high schools were in towns of less than 2500 population; 35.2 per cent have an enrolment of less than 50; 39.0 per cent of 50 to 100; 11.6 per cent of 100 to 150; and 14.2 per cent of 150 or more. The number of schools with an enrolment of less than 150 is constantly increasing as Table I shows.

TABLE I

ENROLMENT IN FOUR-YEAR STATE ACCREDITED HIGH SCHOOLS[2]
(From 1917 to 1925)

Number of schools with an enrolment of:	Year (by 1917 we mean school year of 1917–18)									Per cent of increase
	1917	1918	1919	1920	1921	1922	1923	1924	1925	1917–1925
Less than 50	27	29	40	44	59	63	82	97	94	347
50 to 99	29	41	42	59	68	79	95	93	104	358
100 to 149	11	11	14	16	28	31	36	40	31	281
150 to 199	3	2	4	6	10	13	10	18	18	600
200 or more	11	13	21	18	6	15	7	14	20	181
Total no. of schools	81	96	121	143	171	201	230	262	267	329

The number of high schools employing only three to four teachers also illustrates the predominance of the small high schools in South Dakota. This shows that 60 per cent of our four-year accredited high schools employ only three to four teachers.

* Paper read before the Division of Chemical Education of the American Chemical Society at Richmond, Va., April 14, 1927.

† Numbers refer to bibliography at the end of the article.

TABLE II

THE NUMBER OF SCHOOLS WITH TEACHING FORCES RANGING IN SIZE FROM 3 UPWARD

No. of teachers employed	No. of schools	Per cent of total
3	94	35
4	67	25
5	30	11
6	20	7
7	12	4
8	12	4
9	3	1
10	10	4
11	2	1
12	2	1
14	3	1
16	3	1
18, 20, 22, 23, 24, 25, 26, 28, 58	1 each	3

Persistency of High-School Pupils

On the basis of total enrolment in the high schools for 1920 with ninth grade (first-year high school) enrolment taken as 100 per cent, and following this group through high school the comparative data for South Dakota and the United States are as follows:

	S. D.[3]	U. S.[4]
Numbers enrolled in 9th grade	100	100
Numbers enrolled in 10th grade	81	71.4
Numbers enrolled in 11th grade	68	46.7
Numbers enrolled in 12th grade	61	42
Numbers going on to college	14	24.1

South Dakota, therefore, compares very favorably with the average for the United States as far as persistency in high school is concerned, but it suffers a drop of 40 per cent in the number going to college as compared with the average for the United States. The courses given in high school, judging by the textbooks used, are largely designed to meet the needs of those who expect to go to college.

Source, Preparation, Teaching Load, Average Salary, and Experience of the Teacher

The third factor to be considered is the teaching personnel. It may be surprising to find that of 229 science teachers reporting from the four-year accredited high schools of South Dakota,[5] 50 per cent are graduates of denominational schools; 19.3 per cent, of state universities; 18.8 per cent, of state agricultural schools or colleges; 11.9 per cent, of state teachers' colleges. Of this number, 15.2 per cent of the South Dakota teachers in

four-year accredited high schools came from denominational schools in the state as compared with 4.8 per cent from the state university, 16.2 per cent from the state agricultural college, and 10 per cent from state teachers' colleges. The high-school science teachers prepared in South Dakota institutions are derived from five state schools and six denominational schools, making a total of eleven schools supplying high-school teachers of science in South Dakota.

The average preparation of teachers consists of fifteen semester hours of credit in education with a science training largely in one field and with very few showing credits in the methods of teaching the major subject.

The directory of secondary education of South Dakota for 1924–25[6] reveals that out of a total of 459 instructors who teach science, 31 per cent are serving also as superintendents or principals of the schools, and, in addition, two-thirds of these superintendents and principals are conducting five or six classes per day and teaching a two- or a three-subject combination such as science and history. Of these 459 teachers, 78 per cent are conducting from five to six recitations per day and teaching a two- to three-subject combination. Taking science as 100, mathematics is the subject combined with science in 45 cases, history in 25 cases, English in 16 cases, language in 8 cases, manual training in 6 cases, home economics in 5 cases.

These science teachers,[6] excluding superintendents, principals, and instructors in agriculture and home economics, received an average salary of $1425 for the year 1924–25. On the basis of 218 different science teachers reporting in 1924 and 1925, 17 per cent have one year of teaching experience, 17 per cent have two years; 18.4 per cent, three years; and 11.4 per cent, four years.

On the basis of 231 science teachers[5] reporting on the number of years in the present position, 42.4 per cent are in their present position for the first year, and 32 per cent for the second year. This indicates that nearly 75 per cent of our teachers cannot be thoroughly acquainted with the needs of the students in their particular communities. We have a constantly shifting group seeking a better salary, a lighter teaching load, and better facilities to work with.

Value of Science Equipment[5]

The fourth factor to be considered is the value of the equipment which these teachers have available for the teaching of a given science. The survey shows that the value of the equipment is as follows:

	Average	Median	Q_1	Q_3	Range	No. schools reporting
Chemistry	$387	$355	$222	$462	$50–$1600	46
Physics	377	312	267	469	75–1800	125
Biology	166	152	81	224	20–550	57
Gen. Science	134	102	67	204	10–600	71
Phys. Geog.	65	66	50	92	2–350	25

The preceding data are confined to the high schools with an enrolment of less than 160, since 91 per cent of the four-year state accredited high schools are included in this group and our major problem of science teaching is also in this group.

The first column states the average value of the equipment for each science as: chemistry, $387 based on 46 schools; physics, $377 based on 125 schools. The second column shows the median or measure of central tendency as chemistry, $355. That is, 50 per cent of all the cases fall above and 50 per cent below this value. The third column gives the first quartile as chemistry, $222. This means that 25 per cent of the cases fall below the value given and 75 per cent above. The fourth column states the third quartile as chemistry, $462. That is, 75 per cent of the schools offering chemistry have equipment valued at less than $462 and only 25 per cent of the schools have equipment valued at more than $462. The fifth column shows the range in the value of the equipment. The equipment for chemistry includes valuations as low as $50 and as high as $1600.

These data clearly show the need for carefully outlining the essentials of each science course, for indicating the demonstration and laboratory experiments to be performed in each science, for preparing a list of required apparatus for each science and for indicating the apparatus to be added in order to give a more comprehensive course in a given science. We also need to indicate how the work in a particular science may be adapted to the needs of a given community. Why should one school with an enrolment of 27 in chemistry require $1300 worth of apparatus and another school with an enrolment of 18 only $150 worth for the same science? What is adequate equipment for the various sciences as taught in the high schools of South Dakota? What equipment may be used in more than one science?

The Typical Four-Year Accredited High School

We find, then, that the typical four-year accredited South Dakota high school is situated in a town having a population of 500 and has an enrolment of about 65. Most of the science pupils are enrolled in general science or physics in a class of 10 to 15. This typical school has from three to four teachers, usually with one to two years of teaching experience, and 31 per cent are serving as superintendents or principals, of which 20 per cent have from five to six recitations per day with a three-subject combination. The average value of equipment is about $275 with an average of $140 spent for new equipment each year. The median value of the new equipment purchased is $103; the least money spent for equipment is $15, and the most, $1200, based on 51 schools.

Science Taught Determined by What Teachers Can Teach[5]

The science now taught is largely determined by the previous subject-matter training of the instructor employed. If the teacher has had science

work in chemistry, the one year of regular science for the school is generally chemistry whether it is adapted to the needs of the pupils or not. If this teacher leaves, the new instructor may be prepared to teach biology, so the one year of science required becomes biology. Meanwhile, chemistry equipment is idle and probably not locked up; consequently much of the apparatus is destroyed.

Present Tendencies in Science Offered

It will be of interest to compare the tendencies in the enrolment in the various sciences and the number of schools offering science with a similar study made by Dr. H. I. Jones about 1917 or 1918, and reported in *School Science and Mathematics* for January, 1918, Vol. 18, No. 1, pp. 76–80.

Out of a total of 124 schools reporting in 1917,[7] 114 schools reporting in 1924,[8] and 117 reporting in 1925,[9] the number of schools offering each science is as follows:

Science offered	Year offered 1917	1924	1925	Per cent increase	
General Science	47	91	84	178	..
Physics	71	88	76	107	..
Biology	6	..	25	416	..
Botany*	38	*	15	..	60 (decrease)
Zoölogy*	10	*	9	..	10 (decrease)
Chemistry	21	36	41	195	..
Physical Geography	78	31	21	..	73 (decrease)

* Botany and Zoölogy reported as Biology in 1924 survey.

If we count botany and zoölogy with biology the data for these sciences are as follows:

	1917	1924	1925
Biology	54	66	49

On the basis of total enrolment in each science:

Science offered	Year offered 1917[7]	1924[8]	1925[8]	Per cent increase	
General Science	948	1707	2055	216	..
Physics	903	1132	1107	122	..
Biology	105	*	598	570	..
Botany	674	*	314	..	64 (decrease)
Zoölogy	215	*	185	..	14 (decrease)
Chemistry	394	736	911	231	..
Physical Geography	1314	662	461	..	65 (decrease)

If we count botany and zoölogy as biology the data are as follows:

Biology	994	1136	1128	113%

These tables show that the number of schools offering general science has almost doubled since 1917. Physics has held its own, while botany, zoölogy, and physical geography are rapidly being replaced by the other sciences: physical geography by general science; botany and zoölogy by

biology. This would indicate that we are working toward a science sequence as recommended by the Committee on the Reorganization of Science in the High Schools. Chemistry has doubled but it is offered only in the larger high schools of the state because the notion prevails that it costs more to install, costs more to replace material needed for the course, requires a special room for the laboratory work and because some of our state institutions have discouraged the teaching of this science in the high school because of the lack of competent teachers to handle the work.

The present state course of study requires one year of science chosen from the following: general science, biology, physics, chemistry, physiography. In checking the replies from 117 schools reporting in 1925,[9] we find that 23 per cent offer only one science, 40 per cent offer two sciences and 29 per cent offer three sciences. What is this one year of science? The questionnaire reveals that: 12 schools offer physics; 8, general science; 3, biology; 3, chemistry; and 1, physiography.

These facts again substantiate the statement that the science offered in a given school is determined on the basis of the science the instructor is best prepared to teach while the needs of the students are in the main ignored.

It may be of interest to see what the science combination is in the schools offering two sciences.[9]

16 schools offer general science and physics
9 schools offer general science and chemistry
4 schools offer biology and physics
3 schools offer general science and biology
3 schools offer physics and chemistry
3 schools offer $^1/_2$ year of physiography, $^1/_2$ year of general science and physics
2 schools offer physics and physiography
2 schools offer general science and physiography
2 schools offer $^1/_2$ year of physiography, $^1/_2$ year of biology and physics
1 school offers biology and chemistry
1 school offers $^1/_2$ year of general science, $^1/_2$ year biology and physics.

From this it is apparent that in most of the schools provision is made to offer a science for the first two years and the last two. This is on the basis of general science, physiography, and biology considered as science offered for the first two years of high-school course. The better combinations are general science for the first two years and a choice of physics or chemistry for the last two years of the course.

The questionnaire also asked these instructors to state what science should be offered in our high schools if only one science could be offered. Out of a total of 58 who replied to this question,[9] 28 stated general science;

14, physics; 10, biology; and 4, chemistry. In 50 per cent of these cases the instructors recognize the fact that general science would meet the needs of the students in this scientific age better than a special science such as biology, chemistry, or physics. It is interesting to note that not one recommended physiography.

On the basis of this survey and a detailed study of the actual science contacts of the pupils in the rural communities we may be able to formulate a more definite plan of science instruction which will be better adapted to the needs of the pupil and the community in which he lives.

Such a program would enable us to work out:

1. A reasonable science program for the one, two, three, and four-year high schools with an enrolment of less than 50 to 100, etc.
2. A definite science sequence.
3. A definite alternation of the subjects offered in the first and second years of high school and those offered in the third and fourth years to reduce the teaching load of these more or less inexperienced teachers.
4. A definite scheme of reasonable subject combinations for the teachers.
5. A plan of state certification to make it impossible for a teacher to attempt to teach subjects in which he is not prepared.
6. Some scheme of control in order that the school board shall coöperate with the state department in employing teachers.

Needs of South Dakota High Schools from Science Viewpoint

Then from the science standpoint, this program will enable us to accomplish some much needed improvements, *e. g.*:

1. To work out a definite minimum list of apparatus adequate for the teaching of a given science or science sequence with an additional list of apparatus to be added from year to year to enrich the course. This gradual building up of the science equipment for a given school would then be possible regardless of whether a given teacher remained in the position or not.
2. To prepare a carefully constructed manual filled with helps for the inexperienced teachers, such as lesson plans, preferably based on a definite system with suggested time schedule adequate to teach the unit.
3. The content of the textbook to be used should also be better defined than at present.
4. A combined laboratory and class-room should be designed to take care of the science work and also be available for other classes in order to conserve available floor space in these schools.

First Aids for Teachers in Service

In order to serve better the interests of those now teaching science in our small high schools we need:

1. Carefully planned courses of study in the summer schools of our teacher-training institutions to meet the needs of science teachers in service.

2. A high-school manual filled with plenty of helps for these teachers such as suggestive lesson plans based on a unit system, with suggested time schedules in which to put the unit across to the pupils and detailed suggestions as to how to handle a particular unit, similar to the plan as outlined in the General Science Syllabus of New York State for 1924.

3. Some sort of a clearing house established to furnish the teachers in service help in ordering equipment best suited to their needs and to assist them with any of their problems or difficulties that may arise in their work during the school year.

The writer is of the opinion that the special sciences as such will disappear from the high school and the science sequence will be offered as Science I, II, III with the content of each course covering the whole field of science and the material arranged in the order of difficulty of comprehension by the student and if only one year of science is offered in a given high school, general science will better meet the needs of the pupils than a special science such as physics or biology.

Such a program as outlined above means a considerable amount of detailed work, but we ought to be able to secure a group of instructors in South Dakota who would be able to coöperate in rendering such a service to the state.

Bibliography

[1] Directory of Secondary Schools and Educational Institutions of South Dakota, 1925–1926.

[2] Directories of Secondary Schools and Educational Institutions of South Dakota for 1917, 1918, 1919, 1920, 1921, 1922, 1923, 1924, 1925.

[3] Sixteenth and Seventeenth Biennial Report of the Superintendent of Public Instruction of South Dakota.

[4] Bureau of Education Bulletin No. 14, 1924, pp. 535 and 560.

[5] Science Survey Questionnaire, J. H. Jensen, 1924 and 1925.

[6] Directory of Secondary Schools and Educational Institutions of South Dakota, 1924–1925.

[7] Dr. H. I. Jones, "Science Teaching in South Dakota," *School Science and Mathematics*, **18**, No. 1, pp. 76–80, 1918.

[8] Science Survey Questionnaire, J. H. Jensen, 1924–25.

[9] Science Survey Questionnaire, J. H. Jensen, 1925–26.

It is the man of science, eager to have his every opinion regenerated, his every idea rationalized, by drinking at the fountain of fact and devoting all the energies of his life to the cult of truth, not as he understands it, but as he does not understand it, that ought properly to be called a philosopher. To an earlier age knowledge was power—merely that and nothing more—to us it is life and the *summum bonum*.—C. S. PEIRCE

INTERFERENCE—A CHEMICAL PLAY*

DOROTHY RUDDICK, ELIZABETH WINGER, AND MARCIA CAHALAN, SENIOR HIGH SCHOOL, KEOKUK, IOWA

TIME: Present
PLACE: Living room of a home
CHARACTERS: (In order of appearance)

Atom	brother of *Molecule*
Molecule	brother of *Atom*
Valence	sister of *Atom* and *Molecule*
Ozone	small boy
Zinc, *Lead*, *Barium*, *Silver*, *Aluminum*, *Mercury*	friends of *Atom* and *Molecule*
Radio Announcer, from station KHS	

(*Atom* and *Molecule* poring over books at a table. *Atom* yawns and stops studying.)

Atom: "I can't see why I ever took chemistry, anyway. I haven't done a thing but dig ever since school began. Why do I want to know how to write equations and formulas and all that bunk? It's never going to do me any good, if I'm not a chemist."

Molecule: "Aw shut up and let a feller study! Nobody *made* you take it."

(Both start studying again. Suddenly a noise of falling pans is heard from the kitchen.)

Atom: "Sounds like Valence is having her troubles too. Why'd mother ever leave her to get our meals for, anyway? She doesn't know beans about cooking. Why she even thinks water is hotter when it is boiling vigorously than when it is just boiling."

Molecule: "Will you stop talking about chemistry?"

(Door opens from kitchen and *Valence* enters. Her hair is mussed and there is flour all over her face. She holds in one hand a pan.)

Valence: "Oh, Atom, just look at this bread! What *is* the matter? It's all soggy and flat."

Atom: "Well, what do you expect *me* to know about bread? I'm not the cook, am I?"

Valence: "No, but you have to eat it."

Molecule: "I don't know much about cooking either, but it sure looks to me as if that bread didn't rise. Put any baking powder in it?"

Valence: "NO-o-o, I don't think so. It only said a teaspoonful and I couldn't find it."

Molecule (laughs): "I guess maybe I'd better collect that dollar Mother

* Submitted by P. M. Bail, Senior High School, Keokuk, Iowa.

promised you. Didn't you know that baking powder contains two compounds that form carbon dioxide when water is added? When the dough is cooked this gas escapes and leaves the bread porous. If you forgot your baking powder, that is the reason the bread is doughy."

Valence: "Gee! Where'd you learn all that?"

Molecule: "Why—chemistry, of course."

Valence: "Well, I see where you fellows have a breadless dinner."

(Exit looking mournfully at bread. Both boys start studying again. Suddenly *Atom* upsets the ink bottle on a white napkin.)

Atom: "Oh, golly—look there! On a clean napkin too! Won't I catch it? Wait 'til I get some soap and water. Maybe I can get some out."

(He exits and returns with the soap and water. He works and rubs, but spot does not come out.)

Molecule: "Hold on—I think I can get it out. Go see if there isn't some tartaric acid in the cabinet."

(*Atom* exits and returns with the materials. *Molecule* removes the napkin from the table.)

Molecule: "Here, let it soak a few minutes, and it will soon be out."

(*Atom* puts cloth in pan and works.)

Molecule: "Well, it seems as if my chemistry is coming in pretty handy around here."

(Enter *Valence* with an old tin pan containing apples.)

Valence: "Just how do you like apples cooked?"

Molecule: "Oh, applesauce! But say, you're not going to cook them in that old tin pan are you?"

Valence: "Sure, why not?"

Molecule: "My gosh, girl, don't you know that if you cook anything that contains an acid in a worn tin pan, the hydrogen of the acid will be displaced by the iron under the tin and the iron compound formed doesn't taste good and will discolor the food?"

Valence: "Well, what shall I use? An aluminum one?"

Molecule: "Yes, although the acid would act on aluminum, the metal is protected by a thin coating of oxide which prevents action, and makes it safe to use."

Valence: "Thanks, Molecule, chemistry is sure getting this meal."

(Exit *Valence*. *Molecule* sits down and starts to work again. Outer door opens and *Ozone*, a small boy, enters.)

Ozone: "Molecule, can you lend me some knowledge?"

Molecule: "Sure—now what do you want?"

Ozone: "Well, we fellows are trying to build a camp-fire and, someway, we just can't make it burn."

Molecule: "Well, I suppose you are using green leaves and sticks, aren't you?"

Ozone: "Well—there aren't so *very* many green ones."

Molecule: "Ozone, in building a camp-fire always select materials that burn readily or are combustible, such as wood, paper, and coal. Lay the sticks criss-cross so that air can circulate. Heat causes the fuel to burn, so in starting a fire use materials that have a low kindling temperature—as dry grass or paper. Then your wood and coal will become hot and ignite."

Ozone: "Thanks, I guess I won't return that knowledge."

(Exit. *Atom* stops work. Spot is removed.)

Atom: "It worked great."

(He puts napkin on table and starts studying. Door opens and a gang of boys—*Zinc, Lead, Barium, Silver, Aluminum, Mercury*—enter shouting, laughing, and waving their caps.)

Zinc: "Come on, you fellows, and go to the show."

Atom: "What's on?"

Lead: "Iron plays in 'Slow Oxidation.' Boy, it's heavy stuff."

Molecule: "No, we can't. Have to study for a chemistry test coming tomorrow. Hang around and we'll go to the second show."

(*Atom* and *Molecule* continue studying and the other boys busy themselves around the room. *Barium* picks up evening paper and reads a while.)

Barium: "Gee! Look'it here—(reads)—'Wealthy man commits suicide by inhaling chlorine.' Chlorine? Chlorine? Why that's the poisonous gas they used in the World War."

Lead (throwing pillow at Barium): "Oh can the chatter! Let's get something on the radio."

(*Lead* walks to the radio and tunes in.)

Voice: "Station KHS. Professor Philip Milo Bail of Keokuk High School will now give us a lecture on 'Purification of Water.' "

Lead: "Oh, Bunk! Let's go to the show!"

(Whole gang leaves.)

CURTAIN

Castor Oil Plant Grows Wild in Mexican Fields. Vast fields of castor oil plants grow wild in Mexico, according to information received by the American Chemical Society. There are two varieties, one of woody growth whose seeds yield thirty per cent of oil, and the other of herbaceous habit with seeds yielding about fifty per cent. The natives know the plant as "Higuerilla."—*Science Service*

USE OF THE CHEMISTRY LABORATORY IN AN EMERGENCY FOR TESTING OF FRUIT SPRAY RESIDUE

H. F. COPE, MEDFORD HIGH SCHOOL, MEDFORD, OREGON

That a high-school chemistry laboratory can very profitably serve a community in more ways than one was clearly demonstrated during the 1926 fruit-harvesting season in the Rogue River valley of southern Oregon.

The picking and packing of pears started off in the usual way and under the same methods of cleaning fruit as were in use during preceding years. Just as everything was going on smoothly the exacting requirements of the government's program for the removal of spray residue were felt through the report that a number of cars of fruit had been confiscated at eastern points. This produced intense excitement and also great confusion in the fruit industry because no one seemed to be prepared to meet such exacting conditions and no one seemed to know how near the ordinary methods of cleaning fruit came to meeting government requirements. Practically all operations in connection with picking, packing, and shipping of fruit ceased until the situation cleared. However, fruit was ripening fast and something had to be done in a few days if the fruit industry was to be saved. Through hurried conferences among growers, shippers, and various officials it developed that the only way out of the situation was to make a chemical analysis of each shipment in order to tell whether cleaning operations were successfully meeting government requirements. In order to do this trained chemists as well as laboratory facilities were necessary. The former could be had on short notice while a few small laboratories were available but not sufficient to meet the great demand for testing operations. Immediately, the Medford high-school laboratory became available as a testing station and within a few hours after the decision to make a chemical analysis of each shipment became known the laboratory was a great center of activities in connection with the most important industry in southern Oregon. Laboratory equipment, gas, hoods, etc., were provided and these accommodations were allowed during the remainder of the season.

It goes without saying that in this particular emergency the laboratory proved of inestimable value not only to the fruit growers and shippers but also to the valley as a whole and in this single instance it was worth many times its cost. It was made available when a few days' delay meant losses running into the thousands of dollars and the community can be justly proud of the service it rendered.

The grand, and indeed only character of truth is its capability of enduring the test of human experience, and coming unchanged out of every possible form of fair discussion.—SIR JOHN HERSCHEL

THIS CHART WILL BE THE
SECOND CHART APPEARING
AT THE END OF THIS FILM

THIRD CENSUS OF GRADUATE RESEARCH STUDENTS IN CHEMISTRY

Clarence J. West and Callie Hull, Research Information Service, National Research Council, Washington, D. C.

The Census of Graduate Research Students in Chemistry, 1926, is the third annual compilation of these data to be published by the National Research Council, 1924[1] and 1925[2] having been compiled by the Division of Chemistry, and 1926 for the Division by the Research Information Service.

The general form of the former compilations has been kept intact in order that certain comparisons might be made from year to year, but additional features have been included for 1926 which it is hoped will increase the value of the data. The most important of these is the table giving the number of graduate research students in each of the universities reporting, classified by subject, and subdivided according to the degree for which they are working. This gives at a glance the subjects being investigated at each university, and those universities emphasizing certain research problems in which the reader might be int ested.

Table II

Number of Graduate Students in Various Fields of Chemistry

Summary by Subject

Subject	1926				1925	1924
	Total	M	D	F		
General and Physical	343	143	197	208	332	240
Colloid	58	19	39	24	77	69
Catalysis	31	12	19	14	33	51
Subatomic and Radio	21	5	16	15	27	20
Electro-inorganic	32	20	12	12	42	38
Electro-organic	13	8	5	8	14	18
Photochemistry and Photography	25	7	18	18	19	24
Inorganic	109	48	61	49	86	101
Analytical	54	29	25	59	44	71
Metallurgical	34	23	11	24	28	38
Organic	475	199	276	203	430	422
Physiological	207	94	113	138	196	172
Pharmacological	14	8	6	22	20	30
Pharmaceutical	21	11	10	35	39	20
Sanitary	11	10	1	5	12	9
Nutrition	51	28	23	31	76	48
Food	37	17	20	12	49	35
Agricultural	72	27	45	45	55	91
Industrial and Engineering	274	182	92	106	184	203
Total	1882	893	989	1107	1763	1700

[1] Zanetti, *Ind. Eng. Chem.*, **16**, 402 (1924).

[2] Norris, *Ibid.*, **17**, 755 (1925).

Another new feature is the data concerning faculty members engaged in chemical research. This information should be of value to prospective graduate students as it indicates the research interests of the faculty in each university. Two things should be noted in regard to this information. First, that several of the universities did not classify the faculty by subject, so that they could only be included in the totals; second, that the number given should be taken as the number of the research activities of the faculty, rather than as the number of men engaged in chemical research, as some of the universities apparently have listed the several interests of one faculty member instead of giving his major research as was expected.

The subdivision of the graduate research students according to the degrees for which they are working is included as indicating the scope of the research problem, as that of a man working for his doctor's degree would naturally be assumed to be of wider scope and greater significance than that carried on in fulfilment of the master's degree.

There were 146 universities reporting research in 1926, 23 of these reporting faculty members only.

TABLE III

NUMBER OF GRADUATE RESEARCH STUDENTS REPRESENTED, BY STATES

DATA FOR FACULTY ENGAGED IN CHEMICAL RESEARCH AVAILABLE ONLY FOR 1926

State	1926					1925	1924
	No.*	Total	M	D	F		
Alabama	1	5	5		3	3	11
Arizona	1	3	3		5	6	3
Arkansas	1	2	2		6		2
California	5	91	32	59	59	120	118
Colorado	3	25	15	10	19	26	26
Connecticut	4	57	15	42	52	60	55
Delaware	1	1	1		3		
District of Columbia	4	17	12	5	19	15	10
Florida	1	7	7		7	5	4
Georgia	1				2	7	4
Idaho	1				6		2
Illinois	5	241	103	138	68	203	175
Indiana	4	18	14	4	28	20	26
Iowa	3	140	45	95	39	125	104
Kansas	1	22	13	9	9	23	3
Kentucky	1	6	6		5	13	12
Louisiana	3	20	18	2	15	20	18
Maine	2	2	2		8	5	10
Maryland	2	47	5	42	21	43	39
Massachusetts	14	197	115	82	96	180	189
Michigan	2	84	33	51	37	66	48
Minnesota	1	46	21	25	23	6	94
Mississippi	1	2	2		4		1
Missouri	4	57	41	16	46	37	52
Nebraska	1	25	22	3	15	21	21
Nevada	1	2	2		3	3	3

TABLE III (*Continued*)

State	No.*	Total	M	1926 D	F	1925	1924
New Hampshire	1	1	1				3
New Jersey	2	30	11	19	28	18	24
New Mexico	1				2	1	
New York	15	265	73	192	199	214	200
North Carolina	3	23	10	13	5	25	14
North Dakota	1	1	1		3	8	3
Ohio	11	123	66	57	41	118	85
Oklahoma	1	11	11		4	13	15
Oregon	1	5	5		6	9	8
Pennsylvania	13	72	38	34	60	88	87
Rhode Island	2	21	11	10	3	18	6
South Carolina	2	1	1		2		5
South Dakota	2	3	3		7	16	7
Tennessee	2	10	10		9	7	7
Texas	4	30	26	4	20	30	25
Utah	2	7	7		9	3	9
Vermont	2	2	2		6	3	2
Virginia	5	18	13	5	14	14	16
Washington	2	27	19	8	19	24	31
West Virginia	1	6	6		9	8	3
Wisconsin	3	107	43	64	56	138	118
Wyoming	1				2		
Hawaii	1	2	2		5	1	2
Totals	146	1882	893	989	1107	1763	1700

* No. indicates number of institutions in the state reporting.

SOME DATA RELATING TO CHEMICAL EDUCATION IN THE UNITED STATES

At the Philadelphia meeting of the Senate of Chemical Education in September, 1926, it was voted that certain data on chemical education in the high schools and colleges of the United States be collected. Accordingly state questionnaires were issued by the respective high-school and college Senators. At the Richmond meeting of the Senate in April, 1927, it was voted that the information collected, although incomplete, be summarized, tabulated, and published in the JOURNAL OF CHEMICAL EDUCATION. The following tables set forth the data received to date.

KEY TO JOURNALS TAKEN

1. Journal American Chemical Society. 2. Popular Science Monthly. 3. Scientific American. 4. Science and Invention. 5. Popular Mechanics. 6. Journal of Chemical Education. 7. Science News Letter. 8. School Science and Mathematics. 9. American Medical Journal. 10. Chemical and Metallurgical Engineering. 11. General Science Quarterly. 12. Current Science. 13. American Food Journal. 14. Radio Broadcast. 15. Science Classroom. 16. Scientific Monthly. 17. Science Weekly. 18. Nature. 19. Industrial and Engineering Chemistry. 20. Hygeia. 21. Chemical Abstracts. 22. Chemicals. 23. Science of Everyday Life. 24. Science. 25. National Geographic. 26. Chemical Review. 27. School Review. 28. Electric Journal. 29. Science Review. 30. Scientific World. 31. Journal of Home Economics. 32. American Journal of Science. 33. Physics Review. 34. Chemical Bulletin. 35. Technical Engineering News. 36. Literary Digest.

TABLE I

HIGH SCHOOLS

State	No. schools reported	Average enrolment: Total	Average enrolment: Per cent taking chemistry	Average permanent equipment, apparatus and chemicals: Total	Average permanent equipment, apparatus and chemicals: Per student	Average yearly allowance apparatus and chemicals: Total	Average yearly allowance apparatus and chemicals: Per student	Average yearly allowance, books and journs.	Average Teachers' College credit in: Mathematics	Physics	Chemistry	Percentage of Schools using outline of A.C.S.	Journals taken
Alabama	50	335.5	12.7	$ 984.10	$ 34.10	$142.00	$ 5.53	$ 37.08	13.1	9.8	21.8	47.6	1, 2, 3, 4, 5, 6, 7, 8
Arizona	26	299.7	13.6	2128.00	94.30	227.10	12.18	32.00	13.3	11.6	23.8	36.7	3, 2, 6, 8, 1, 5, 9, 4, 10
California	96	479.0	11.6	1641.72	70.58	308.00	10.15	45.85	23.8	21.5	37.3	38.7	11, 6, 10, 3, 8, 2, 4, 7, 12, 13, 14, 5, 15, 1, 16, 17, 18, 19, 20, 21, 22, 24
Colorado	79	236.0	15.5	1205.50	32.84	211.20	5.75	55.27				62.6	3, 4, 1, 21, 2, 12, 6, 5, 24, 15, 8, 7, 18, 25
Delaware	13	286.7	11.2	803.77	47.27	115.33	5.30	23.00	15.1	9.6	26.5	33.3	3, 6, 4, 2, 8, 1, 21, 19
District of Columbia	6	1244.0	12.9	7866.66	114.91	370.80	5.79	50.00					2, 5, 7, 8, 6, 10
Georgia	27	248.5	18.6	1364.00	40.05	155.83	11.17	44.16	9.6	8.6	15.9	47.6	24, 5, 3, 6, 2, 8
Illinois	101	789.7	7.5	2346.16	69.44	306.76	6.40	43.49	17.3	14.2	35.8	56.8	6, 3, 16, 8, 4, 5, 2, 11, 15, 12, 7, 14, 1, 21, 10, 26, 19, 27, 24
Indiana	54	728.1	9.5	2526.80	48.44	314.38	6.60	39.50	17.3	16.4	36.6	59.2	6, 8, 24, 3, 19, 2, 1, 4, 16, 7, 5
Iowa	38	489.1	10.4	1888.13	28.68	240.64	8.36	24.47	15.2	12.5	38.1	58.1	6, 1, 3, 8, 2, 5, 16, 7, 4
Louisiana	21	424.1	12.1	2039.00	47.30	140.40	7.63	46.00	14.1	9.8	19.0	65.0	6, 2, 12, 21, 1, 19, 24, 16, 7
Maryland	65	304.1	19.4	1013.17	22.23	120.18	7.10	22.50	13.0	9.7	21.2	43.9	6, 3, 8, 14, 5, 19, 1, 21, 28, 2, 10, 24, 4, 15, 11, 12, 29, 7
Massachusetts	25	1133.5	10.2	2531.25	33.12	224.00	3.27	16.66	12.8	12.2	27.1	64.7	6, 8, 3, 2, 1
Michigan	214	353.0	13.8	1347.86	43.41	186.48	3.74	23.90	15.3	13.1	23.5	47.2	11, 8, 6, 3, 2, 5, 4, 7, 24, 16, 1, 21, 10, 19
Missouri	195	98.0	9.4	1417.50	77.40			188.37					
Nebraska	49	362.0	12.7	1088.83	21.77	169.32	3.38	34.43	13.3	9.8	21.5	68.3	
New Hampshire	44	161.1	15.6	949.16	51.00	128.17	6.15	28.00	12.1	10.3	20.9	55.5	2, 3, 7, 5, 8
New Jersey	25	905.3	12.8	4240.00	119.45	319.70	4.50	95.00	11.2	8.1	21.2	40.0	3, 6, 5, 14, 18, 8, 11, 2, 24, 1, 7, 4
New York (Syracuse Sec.)	23	507.2	16.6	1350.00	48.40	168.00	5.81	26.42	13.7	13.6	26.3	23.8	4, 3, 6, 8, 2, 7, 24
North Dakota	42	128.4	20.7	581.07	32.00	127.48	8.01	14.62	26.9	22.9	37.1	44.4	3, 2, 8, 4, 6, 30, 5
Oregon	78	336.9	12.2	1190.92	38.65	231.50	7.33	45.18	16.9	12.5	28.1	38.8	
South Dakota	74	164.0	12.2	857.00	42.85	135.00	6.75	23.00	14.0	9.0	19.0	32.4	19, 18, 33, 2, 3, 6, 8, 11, 31, 4, 5, 25, 32, 1, 10, 26, 12
Vermont	27	237.0	15.9	1630.00	92.37	118.75	5.22	24.62	7.9	6.3	11.8	61.1	3, 16, 6, 2, 1, 8, 18, 20, 35
Virginia	194	187.0	11.7	505.00	32.30	95.30	6.94	16.37	10.1	8.4	15.4	32.8	3, 2, 6, 8, 4, 5, 16
Washington (Public)	193	280.0	14.6	1158.00	28.24	181.00	4.41	25.00	17.2	13.7	31.9	34.2	
(Private)	9	174.0	10.3	2157.00	119.83	145.00	8.05	18.00	18.0	19.0	30.0	44.4	
West Virginia	60	142.0	15.1	970.92	57.26	189.09	10.60	22.14	13.9	10.7	22.2	3.3	4, 24, 3, 16, 6, 25, 2, 7, 8, 12, 14, 5, 15, 36
Wisconsin	35	439.0	13.3	2007.13	34.60	252.00	5.56	55.80	16.5	13.1	33.3	35.3	1, 29, 6, 5, 14, 2, 8, 12, 25, 7, 3, 16, 20, 18, 4, 19, 10, 34

TABLE II

COLLEGES AND UNIVERSITIES

State	Number of institutions reported	Enrolment				Average permanent equipment apparatus and chemicals		Yearly allowance Chemicals and apparatus		Books and journals	Average no. instructors and assistants in chemistry
		Total average	Per cent taking chemistry	Per cent majoring in chemistry	Average no. taking grad. work	Total	Per student	Total	Per student		
Alabama	1	850.0	24.0	15.0		$ 20,000.00	$102.04	$ 2,500.00	$12.75	$ 250.00	8.0
California	15	1697.0	16.9	2.6	18.8	16,940.00	59.02	2,675.00	9.32	205.00	6.4
Colorado	7	1088.0	26.3	4.0	3.2	20,953.00	73.26	3,114.28	10.85	418.57	6.2
Connecticut	4	1253.0	35.5	2.5	21.6	29,625.00	66.57	5,543.75	10.21	591.66	15.8
Dist. of Col.	3	2368.0	23.0	5.0	44.0	28,666.66	52.59	3,333.33	6.11	412.50	10.3
Florida	4	618.8	14.2	2.4		8,750.00	99.43	2,166.66	24.62	175.00	2.0
Georgia	14	706.0	21.8	4.5	3.6	6,766.66	43.94	1,361.54	8.19	77.92	7.0
Illinois	25	1505.0	20.4	1.9	5.7	13,918.80	45.33	4,034.10	13.14	178.40	8.1
Indiana	25	1071.1	20.3	3.1	15.0	14,096.45	64.96	2,342.10	10.80	174.21	5.2
Iowa	13	1181.1	16.5	1.2	53.0	96,509.50	494.92	4,802.45	24.53	305.00	8.5
Louisiana	6	1393.1	28.6	1.1		175,200.00	436.91	2,666.66	6.65	220.00	7.5
Maine	4	835.5	27.5	3.4		20,933.33	91.01	4,933.33	21.44	166.66	7.5
Maryland	9	349.3	31.2	3.7	37.5	15,188.37	139.25	3,112.22	28.55	234.37	5.4
Michigan	12	1008.3	24.7	4.6	10.0	66,050.33	225.10	3,225.00	12.71	173.63	7.3
Minnesota	9	1580.4	22.8	2.2		26,505.77	72.81	4,327.77	11.88	128.56	10.0
Mississippi	4	840.3	30.8	2.1		25,000.00	97.28	3,250.00	12.59	383.33	7.0
Missouri	16	1773.7	22.9	2.0	1.5	48,699.68	119.55	4,212.81	10.35	236.15	6.2
Nebraska	14	467.1	20.1			4,196.15	44.68	658.46	7.00	48.75	
Nevada	1	830.0	24.0	3.8		3,000.00	15.07	2,500.00	12.56	150.00	5.0
New Hampshire	1	2100.0	36.0	2.4		17,000.00	22.48	5,000.00	6.02	750.00	8.0
New Jersey	1	2400.0	25.0	0.7	25.0	22,000.00	26.66				27.0
New Mexico	1	400.0	35.0	4.0		1,000.00	7.14	1,200.00	8.00	75.00	3.0
New York	1	1717.0	88.0	2.4	20.0	60,000.00	62.43	25,000.00	27.06	1,000.00	38.0
North Dakota	1	944.0	51.0	16.0		120,000.00	306.98	4,000.00	10.23	300.00	7.0
Oregon	6	849.4	30.0	3.6	2.6	29,800.00	117.25	1,920.00	7.52	350.00	8.6
Pennsylvania	26	1264.0	31.4	6.2	8.1	24,802.16	63.50	4,881.81	12.29	174.05	7.1
Rhode Island	2	1250.0	33.5	3.6	11.0	38,000.00	90.43	750.00	1.78	900.00	10.0
Tennessee	1	1238.0	18.0	16.0		48,000.00	215.24	5,000.00	22.41	600.00	19.0
Utah	6	1043.5	21.3	0.7	3.6	8,761.00	39.63	1,640.00	7.42	75.00	4.8
Virginia	16	436.3	25.8	4.2	8.5	7,987.50	70.68	1,480.00	13.09	153.00	4.3
Washington	11	1386.5	15.9	6.4		5,763.63	26.48	1,970.27	9.85	249.42	6.1

COMBUSTION DEMONSTRATIONS*

JOHN SELLERS, UNIVERSITY OF ILLINOIS, URBANA, ILLINOIS

Most high-school teachers of chemistry are called upon at some time to give before the student body a short demonstration of some interesting chemical phenomena. Such a task may be looked upon as an opportunity to accomplish three very definite ends: first, to stimulate interest in the subject of chemistry among the students not already taking it; second, to exercise the originality of beginning chemistry students in thinking out new and novel methods of experiment; and third, to present life-size realities for subsequent reference in the class-room. It is found that well-chosen experiments, presented in an attractive manner are very successful in accomplishing these ends. What follows is a description of some combustion experiments which have been somewhat successful in this kind of work.

The experiments consist in the observation of the combustion of liquid fuels, their flashing points, flame color, carbon deposit, and flame volume; in the observation of the behavior of pure gases in the Bunsen burner; and finally in the explosive combustion of gaseous mixtures.

The experiments are best carried out on a rather long table covered with asbestos paper. Although the experiments should never require their use, a fire extinguisher, Pyrene type, as well as an open beaker containing carbon tetrachloride should be within easy reach and visible to all present. These serve to illustrate to the students care and forethought on the part of the instructor in view of the fire hazard inherent in the experiments.

The following apparatus and materials are required: continuous source of heat—gas flame or alcohol lamp; six or more Petri dishes; several glass rods; three 500 cc. wide-mouth, glass-stoppered bottles; asbestos board for extinguishing flames; liquid fuels—toluene, ligroin, carbon disulfide, ether, alcohol, amylene; balloons filled with gases—hydrogen, carbon monoxide, hydrogen sulfide, carbon dioxide, and oxygen; ring-stands and rings for supporting the balloons; Bunsen burners and pieces of soft rubber tubing 30 inches long; short pieces of glass tubing and rubber bands for connecting the balloons to the burners; open top bell jar, size and shape of a two-liter acid bottle, fitted with a one-hole rubber stopper and glass nozzle.

In introducing the subject mention will certainly be made of the tremendously great importance of the chemical process called combustion. It may be said that there is no other general type of chemical reaction over which we have any appreciable control that is more important in

* Paper delivered at a meeting of the Illinois Association of Chemistry Teachers, Nov. 19, 1926.

everyday life and in industry than that of combustion. We use it in cooking our food, warming our homes, driving our automobiles; and industry uses it in manufacturing hundreds of articles. In fact, without combustion the world we live in would be a very cold one and life as we know it would probably not exist at all.

Combustion may be defined as the chemical reaction between one substance which we call a fuel and another which keeps the reaction going, or, in other words, supports the combustion. There are many kinds of fuels—solids, liquids, and gases—but only one universal substance that supports combustion, namely, oxygen. The combustion of solid fuels is quite a common thing; we raise the temperature of the fuel to the kindling point and the reaction continues, the kindling temperature being maintained by the heat of combustion itself. Good liquid fuels are very volatile so that the atmosphere over the fuel in an open vessel is a mixture of the fuel and air.

Pour out very small quantities (two or three cubic centimeters) of the liquid fuels from test tube supplies into the Petri dishes placed at least six inches apart. Heat one end of a glass rod to red heat in the flame and pass it over the various fuels. It will be found that some will take fire very easily from the heated rod while others will take fire only when the hot rod is dipped into the liquid. The flames may then be extinguished and the Petri dishes placed closer together. If ether or carbon disulfide are placed at one end of the row and the other liquids touched successively with the hot rod until one of the above is reached, ether or carbon disulfide will ignite and the rest will follow consecutively down the line. Furthermore, it will be observed that some of the fuels burn with a blue flame while others have very yellow flames. When the flames have gone out certain ones will leave behind a heavy deposit of carbon, characteristic of the fuel.

In two separate bottles place one cubic centimeter of ether and one cubic centimeter of carbon disulfide. Stopper and shake. Then note the ease with which they will ignite on the application of a hot rod. The carbon disulfide has the lower kindling temperature, apparently, although its boiling point is ten degrees higher than that of ether. If patience and time permit, the flame in the carbon disulfide bottle may be made to follow the glass rod, giving the appearance of a trail of fire following in the path of the moving rod. This will happen when the percentage of air and carbon disulfide gas in the bottle is just right. Fuel gas may be taken from the mains into a glass bottle and ignited with a hot rod. It will appear that the kindling point of the gas is actually higher than that of ether or carbon disulfide vapor. It may, furthermore, be shown that combustible liquids when mixed with carbon tetrachloride become noncombustible, and this property of carbon tetrachloride is utilized in the manufacture of the common cleaning reagent called "Carbona."

A study of the behavior of pure gases in the act of combustion in the Bunsen burner is obviously more difficult because of the difficulty involved in collecting and confining the gases. The gases are prepared by the usual laboratory methods and collected in two-liter acid bottles. They are then forced into the balloons using the apparatus shown in Fig. 1. This consists of the gas-filled bottle provided with a two-hole rubber

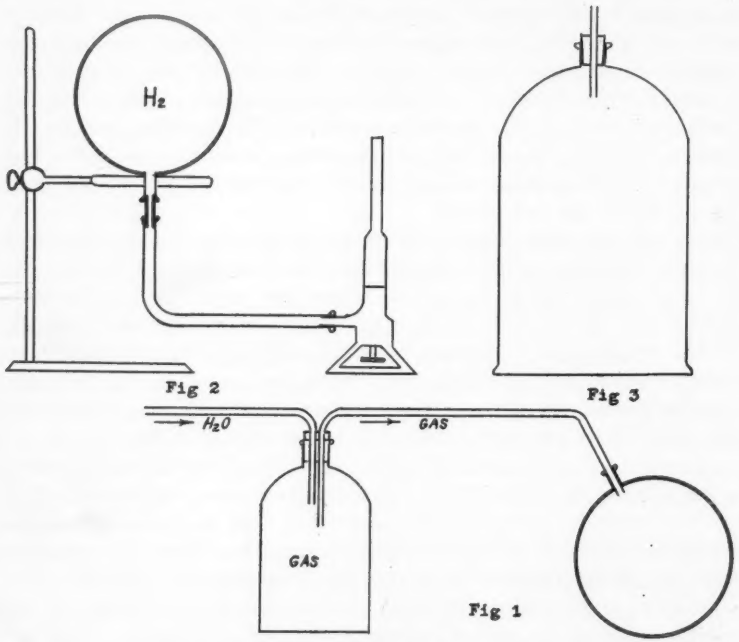

FIG. 1.—Device for filling the balloons with gas.

FIG. 2.—Gas-filled balloon attached to burner ready for lighting.

FIG. 3.—Bell jar for simultaneously burning hydrogen and mixing it with air until an explosive mixture is obtained.

stopper and glass connections into which water from the mains is forced, thus forcing the gas into the balloon. A pinch clamp will be used to confine the gas in the balloon while a new gas-filled bottle is being connected in the system. About four bottles of gas will fill a good-sized balloon. When filled, the balloon is connected to a burner, the rubber tubing being pinched shut by a screw clamp. When none of the gases are available from drums the task of filling the balloons is quite great; but most students delight in doing it so that there is no want for help. Carbon mon-

oxide is conveniently prepared from formic acid and sulfuric acid. This should be placed in the hands of a student *only* when there is very close supervision by the instructor. Very great care must be exercised in collecting this gas for its physiological effects when breathed into the lungs are extremely harmful. The balloon which is to contain it should first be tested by blowing air into it. It should be noted also that hydrogen sulfide cannot be kept long in a balloon as it tends to dissolve in the rubber on the inside and evaporate from it on the outside. If it is to be used, it should be put into the balloon as near the time for the experiment as possible.

The balloons with gas being in place and the burners adjusted, the gases are ignited. The carbon monoxide flame is a characteristic blue. The flame color of the hydrogen sulfide is about the same as that of carbon monoxide. Sulfur dioxide fumes from the hydrogen sulfide flame are distinctive from their odor. Hydrogen gives nearly a colorless flame. An attempt is made to ignite the oxygen which issues from the burner. It, of course, does not burn but causes the splinter to glow much brighter. At this point the rôle of oxygen in combustion may well be emphasized again. When the carbon dioxide gas is allowed to issue through the burner and an attempt is made to light it, it is found that it neither burns nor allows the splinter to burn. A little of one of the liquid fuels used above may be ignited in one of the Petri dishes and oxygen directed upon it, and the result contrasted with what happens when carbon dioxide gas is directed upon it in a similar manner.

The carbon monoxide gas should be allowed to burn up entirely; after the hydrogen sulfide flame has been observed the balloon containing the remainder of the gas should be placed in the hood. The hydrogen flame will be observed and the flame shut off, the remainder of the gas being reserved for the final experiment. It should still contain enough hydrogen to have a diameter of at least twelve inches.

Fig. 3 shows the mounted bell jar which should be supported several inches above the table by a burette clamp and ringstand. A sheet of paper is fastened securely around the bottom. When ready to insert the hydrogen a small hole is punched in the paper with a pencil point. Then the hydrogen balloon is attached to the nozzle and the hydrogen forced from the balloon into the jar. The hydrogen is then ignited at the nozzle and as it escapes it burns, at the same time drawing in air at the opening below. When the mixture of hydrogen and air has attained explosive proportions an explosion will occur. This explosion is entirely harmless since the expanding gases have practically no resistance in the downward direction.

A CHEAP LABORATORY SODIUM PRESS

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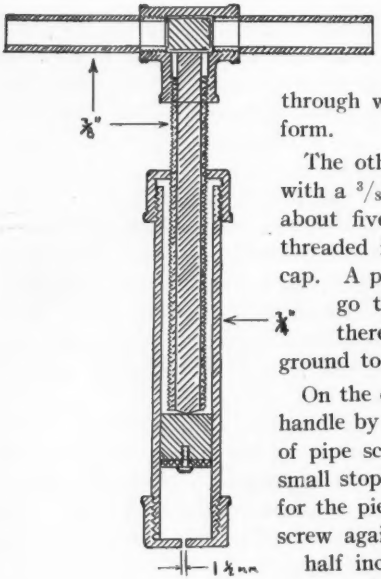
A very simple sodium press for laboratory use can be made as follows: A piece of three-fourths inch gas pipe of convenient length (three or four inches will serve), machined on the inside sufficiently to insure smoothness and uniformity of bore, is used as the cylinder of the press. It is threaded at each end to accommodate regular pipe caps. One end must be threaded far enough that the cap will screw on until the end of the cylinder is tight against the inside end of the cap.



Through this cap drill a small hole of $1^1/_2$ or 2 mm. diameter through which sodium can be forced in wire form.

The other cap must be drilled and tapped with a $^3/_8$" pipe thread. A piece of $^3/_8$" pipe about five and one-half inches long is now threaded its entire length to screw into this cap. A piece of iron rod of such size as will go tightly into this $^3/_8$" pipe is fitted therein with a half-inch protruding, and ground to a beveled point.

On the other end of this pipe is fitted a T-handle by using a gas "tee" with short pieces of pipe screwed into it. It is well to put a small stop in the "tee" between pipe handles for the piece in the other side of the "tee" to screw against. This may be made of a one-half inch length of $^1/_4$" rod or pipe. Drill through the side connection of "tee" and rivet it, thus making this connection permanent.

Machine a steel plug as a piston block one inch long to fit as tightly as will work conveniently inside the three-fourths inch cylinder. Make a shallow indentation with a $^3/_8$-inch drill in one end of this plug in which the beveled end of the screw will work. To insure an absolutely tight fit a composition gasket may be fastened to the front end of this plug with a machine screw.

The pieces are now ready for assembling. Place the small block in the end of cylinder with the shortest threading, indented end out. Next screw on the cap with the tapped hole and into it connect, with a few turns, the T-handled screw which is to be the piston shaft of the press.

The next operation is to fill the cylinder with freshly cut sodium. The

pieces should be cut as large as possible, a square piece may be rounded with a wood mallet. After the cylinder is filled, as quickly as possible screw the cap on tightly for this end of the cylinder.

The press is now ready for operation which is accomplished by screwing in the piston, and the sodium wire will exude through the small hole in the other end.

If measurements are correct the cylinder will be empty when the T-handle comes against the cap into which the piston rod screws.

To refill, unscrew the piston rod until nearly out, push back the piston block and fill as before.

This press has been satisfactorily used in this laboratory for several years.

UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces the following open competitive examination for Associate Physical Chemist.

Applications for associate physical chemist must be on file with the Civil-Service Commission at Washington, D. C., not later than August 9th.

The examination is to fill vacancies in the Bureau of Chemistry and Soils, Department of Agriculture, and in positions requiring similar qualifications.

The entrance salary in the Departmental Service at Washington, D. C., is $3000 a year. A probationary period of six months is required; advancement after that depends upon individual efficiency, increased usefulness, and the occurrence of vacancies in higher positions. For appointment to the Field Service the salary will be approximately the same.

The duties in the Bureau of Chemistry and Soils will be to conduct research studies and technical investigations pertaining to fires in farm products, with special attention to spontaneous combustion and deterioration of hay, grain, cattle feeds, and other agricultural products, and the development of methods for their control and prevention.

Competitors will not be required to report for examination at any place, but will be rated on their education, training, and experience; and a publication or thesis to be filed with the application.

Full information may be obtained from the United States Civil-Service Commission, Washington, D. C., or the secretary of the board of United States civil-service examiners at the post-office or customhouse in any city.

Chemical Digest

ABSTRACTS

The Atmosphere: Origin and Composition. W. J. HUMPHREYS. *Sci. Mo.*, **24,** 214–9 (March, 1927).—It is believed that all matter consists of some combination or assemblage of two things as yet unresolved—the electron and the proton. These exist in equal quantities in all matter. Hence, wherever matter occurs in great quantities, as in a star or a planet, one may expect to find every possible combination of electron and proton, *i. e.*, all the chemical elements and such of their compounds as the existing temperatures may favor. Every heavenly object, therefore, has the makings of an atmosphere. The atmosphere of the earth formed because of a difference in the effect of gravity and the volumes of steam, carbon dioxide, nitrogen, hydrogen, and other gases let loose through eruptions in the earth's crust. It is probably because of the activity of oxygen at high temperatures and the fact that it has not been detected in volcanic gases that it is not of volcanic origin. Other possibilities of its origin were given as an over supply at the beginning, from plants or from lightning. Carbon dioxide was the first of atmospheric gases to be discovered. This was followed by the discovery of nitrogen, then oxygen. The rare gases were discovered many years later. The nearly constant composition of the air is due to convection and wind turbulence. The fact that meteors are fired at distances beyond the upper level of ordinary oxygen leads H. to suspect the presence of monatomic oxygen at the greater heights. This might be formed by the action of very short wave-length insolation. G. W. S.

Through a Chemical Lens. K. GEORGE FALK. *Sci. Mo.*, **24,** 220–4 (March, 1927).—The life process of an individual of any species represents a series of changes which are chemical in character. Life processes viewed from the chemical standpoint are as yet very imperfect but the results are of considerable value. The inorganic constituents of matter from various living sources have been determined and the organic constituents have been extensively studied. The results obtained do not give a picture of the whole of a life process. In conjunction with Miss Helen M. Noyes, F. has been studying enzyme action in an attempt to obtain a truer picture of the chemistry of life processes. A brief discussion of the method is given. G. W. S.

A Mighty Faith. A. W. BELDING. *J. Educ.*, **105,** 396 (April, 1927).—A review of the progress of education presenting figures so impressive as to amaze even those who make it their life work. Six and one-half billion dollars invested in education in the United States! This is sufficient to buy out the country's wealthiest corporation, U. S. Steel, and in addition the American Telephone & Telegraph Company, The Standard Oil Company of N. J., and General Motors, and have a fair amount of change remaining. More money is spent annually to run our schools than to run our government, nearly two and one-half billions per year. Nearly a million teachers are employed and about 27,000,000 students are enrolled. In the past 35 years attendance in normal schools has increased 331 per cent; in colleges and universities, 445 per cent; in all secondary schools, 946 per cent; in public schools, 1570 per cent; and in kindergartens, 1882 per cent. "The present support of education," states the author, "is the most magnificent testimonial ever written to any body of devoted men and women since the world began." A. P. B.

Visual Instruction and Class-room Instruction. R. H. JORDAN. *Educ. Screen*, **6,** 117 (April, 1927).—"Some important recent developments in the field of visual education are extremely significant with reference to the trend of this important phase of educational method," states Dr. Jordan, professor of education at Cornell. "One of these is the beginning of an elaborate series of studies having for their objective the development of the type of film most suited for class-room work. This research will be directed by the Eastman Laboratories. Another is the establishment by Yale University of a Department of Visual Education in her graduate school. Many educators, thinks the author, are yet unconvinced of the real usefulness of visual education as a tool of the teacher. The article reviews in a thorough-going manner the various arguments pro and con and admirably fulfils the expressed purpose of the author of

"suggesting some bold outlines for the consideration of those who have felt a certain helplessness regarding the whole matter." A. P. B.

Chemical Engineering Curriculum—Nomenclature and Division of Time. W. L. BADGER. *Trans. Am. Inst. Chem. Eng.*, **17**, 176–88 (1925).—Outside of the fundamental courses, the names of chemical engineering courses are often misleading and the subject-matter varies greatly at different institutions. Due to local conditions the proportion of time devoted in a four-year course to pure chemistry, chemical engineering, and cultural subjects varies. The average time spent is about 14 per cent cultural studies, 30 per cent chemistry, 10 per cent chemical engineering, 21 per cent other engineering, and the rest in physics, mathematics, and other sciences.

In the discussion that followed the paper, it was urged that descriptive courses be abolished, as the subject-matter could be mastered more cheaply by reading a book covering such material. The other courses should be reorganized so that the name would tell what was included in the subject-matter. G. B. H.

Chemical Engineering. What It Is and Is Not. ARTHUR D. LITTLE. *Trans. Am. Inst. Chem. Eng.*, **17**, 169–76 (1925).—Chemical engineering is defined as being "not a composite of chemistry and mechanical or civil engineering but a branch of engineering, the basis of which is those unit operations which in their proper sequence and coördination constitute a chemical process as conducted on an industrial scale." It is the business of the chemical engineer to transform a test tube or laboratory process carried out in glass containers to an industrial scale where very different kinds of apparatus must be used. He must be well grounded in the fundamental science, know where to find information in the literature, and be able to express himself in the language of engineering. G. B. H.

Qualifications of Faculty for Teaching Chemical Engineering. W. K. LEWIS. *Trans. Am. Inst. Chem. Eng.*, **17**, 203–13 (1925).—As the personality of a teacher is of great importance, it is essential that the best man possible be picked to teach chemical engineering. He must have technical ability, sustained practical experience, breadth of vision, alertness, and must be well grounded in the fundamental sciences; as well as enthusiastic about teaching as a profession. Men of outstanding ability should be chosen for the faculty and should be supplemented with young assistants doing graduate work. The cream of young men will be drawn to an institution which has such men in charge and which at the same time offers adequate opportunities for research and study.

It was urged in the discussion, that freshmen should not be left in the hands of inexperienced teachers but should come in contact with the best men possible. G. B. H.

Entrance Requirements for Courses in Chemical Engineering. J. H. JAMES. *Trans. Am. Inst. Chem. Eng.*, **17**, 188–202 (1925).—Due to the large number of students going to the public high schools, it has been impossible to maintain high standards of scholarship. Consequently, the freshmen who enter college are poorly prepared and the mortality is high. The method of having separate high schools for those who wish to prepare for college is being tried in some cities.

Many graduates of high schools are unable to meet the entrance requirements of the engineering colleges especially in mathematics. Some colleges place the poorly prepared students in special sections where their high-school mathematics are reviewed. To improve the quality of the students entering the engineering schools the use of entrance examinations is advocated, especially for students who are not in the upper third of their high-school class. Freshman week in the fall, freshman advisors, postponement of fraternity rushing to the sophmore year are all needed.

In the discussion it was brought out that California seems to have worked out a satisfactory method of admitting students. The university accepts those students recommended by the principal of the high school but the place of the high school on the accredited list depends upon the record of its graduates at the university so the principal is careful whom he recommends. The graduate whom he does not recommend must take entrance examinations; consequently, those who intend to go to college study in high school to avoid taking the examinations.

Placement examinations given by the department of psychology at Iowa show that the lowest 10 or 20% in the examination do not get through the freshman year. They are often advised to drop out before they waste their own and the university's time. The practice of having engineers visit the high schools to tell the boys what engineering is, and what preparation is needed as well as to discourage those without ability was recommended. G. B. H.

Again the Open Door in Education. F. D. BOYNTON. *Sch. and Soc.*, **25**, 327–34

(Mar. 19, 1927).—The following steps are suggested toward the solution of present educational difficulties: (1) a survey of higher institutions of learning to ascertain existing conditions; (2) provision by the state of adequate educational facilities throughout the entire school system; (3) provision of higher training for those fitted to undertake such training; (4) a reorganization of college courses and the orientation of freshmen in their college work; and (5) requirement by colleges of demonstrated teaching ability on the part of their faculties. K. S. H.

Chemical Engineering Laboratory. A. W. HIXSON. *Trans. Am. Inst. Chem. Eng.*, **17**, 230–43 (1925).—A chemical engineer must know how to do things and this training is best obtained in the laboratory. After studying the basic operations of chemical engineering, the students at Columbia are given a laboratory course in which industrial operations are duplicated as nearly as possible. Each squad of four men is assigned a study of some operation, evaporation for instance, and is expected to work out the processes by itself. After carrying out a number of these unit operations groups are assigned several manufacturing problems and the student gets a chance to test his knowledge and ability. Theory and practice are thus coördinated, the student gets an idea of the properties of materials, understands basic operations and process development and in addition develops his initiative, self-confidence, judgment, etc.

It was brought out in the discussion that some colleges use the coöperative system where part of the time is spent in some plant and part of the time in college. This can be successful, only if the university is situated so that there are a number of nearby industries to work with. G. B. H.

Local Administration of Chemical Engineering Courses. H. A. CURTIS. *Trans. Am. Inst. Chem. Eng.*, **17**, 243–62(1925).—If the chemical engineering department cannot be an independent unit, it is better to have it under the chemistry department than the engineering. Professor Parr, on the other hand, thinks that in most cases the chemical engineering department should be subordinate to the department of chemistry and not independent. In this way the chemical engineers keep in contact with a chemical atmosphere.

H. C. Parmelee pointed out that there should not be a conflict between chemical engineering and chemistry. Chemical engineering deals with industrial production, while chemistry is concerned with research and investigation. There must be men trained for both fields. G. B. H.

Permanent Standard for the Determinatipn of Hydrogen-Ion Concentration. ABRAHAM TAUB. *J. Am. Pharm. Assoc.*, **16**, 116–9(1927).—Seventy-three permanent standards are made by blending solutions of inorganic salts containing the ions Co^{++}, Fe^{+++}, Cu^{++} covering a p_H range of 1.2 to 9. These standards are notable for their stability and ease of preparation. The indicators chosen were found reliable and least subject to salt airs by use of 20% neutralized alcoholic solutions. The indicators themselves are made permanent for a long time without decomposition and may be used in buffered as well as unbuffered solutions. J. C. K., JR.

Length of Course in Chemical Engineering. D. D. JACKSON. *Trans. Am. Inst. Chem. Eng.*, **17**, 213–5 (1925). **Four-, Five-, and Six-Year Chemical Engineering Curricula.** J. R. WITHROW. *Trans. Am. Inst. Chem. Eng.*, **17**, 215–30 (1925).—The question is whether the chemical engineering course should be four, five, or six years, and if longer than four years should the extra time be spent on additional engineering subjects or on cultural subjects? It is probably advantageous to have two or more types of courses, a four-year course leading to a B.S. degree for the general run of engineers and a five- or six-year course with a B.S. given at the end of four years and a Ch.E. degree at the completion of the course for a more selected group of men. This extra training may be obtained in the graduate school and a Doctor's degree be granted at the end of seven years. The cultural courses may be at the beginning with a pre-engineering year or so in the academic college. A good four-year man will be able to get the extra education by himself while engaged in industrial work. G. B. H.

A Color That Eats into Fabric. ANON. *Chemicals*, **27**, 29 (Feb. 28, 1927).—A new type of dyeing process has been developed whereby a variety of surprising color effects can be obtained. The process makes promise of setting new fashions in hats, ribbons, stockings, etc. C. R. KINNEY

Some of the Newer Solvents. ANON. *Chemicals*, **27**, 17 (Mar. 14, 1927).—An interesting discussion of the manufacture and uses of some of the newer solvents of the industries. C. R. KINNEY

Romance of the Newer Alcohols. E. FRANKLAND ARMSTRONG. *Chemicals*, **27**, 21 (Mar. 14, 1927).—Abstract of a paper by Dr. Armstrong in which the rôle of the chemist

in developing new solvents is emphasized. Especially interesting in connection with the preceding article. C. R. KINNEY

How Uncle Sam Is Assisting the Development of Two Great Natural Resources—Potash and Oil Shale. ANON. *Chemicals*, **27**, 5 (Mar. 28, 1927).—A review. C. R. KINNEY

Uses of Pigment on Leather. ANON. *Chemicals*, **27**, 19 (Mar. 28, 1927).—The pigment dyeing of leather is becoming very important and the purpose of the present article is to explain the underlying principles and classes of dyes used in the industry. C. R. KINNEY

High-School Natural Sciences and College Achievement. ROBERT L. HOLBROOK AND C. C. CRAWFORD. *High-School Teacher*, **3**, 86 (1927).—The problem of this study is to discover the relation between the sciences studied in high school and success in college work as measured by grades. Data for this study were secured from the registrar of the University of Ohio for all the members of the freshman class, a total of 488 cases.

The study shows that nearly all (98.7%) students offer some science for admission to the university and about two-thirds (64.4%) take some science the first semester of the freshman year, but the particular sciences studied in college are not the same as those studied in high school. Boys take a greater amount of science than girls do; the tendency being for the boys to take physical sciences and the girls biological sciences. Tables given in this study show that high-school students taking physics and chemistry tend to be of slightly higher average intelligence than those taking biology and general science. The percentage of students taking chemistry in high school is less than any other science while in the university it is the greatest. The only college subject in which the kind of previous science preparation seems to be important is chemistry. It appears that biology in high school is associated with lower college chemistry grades than either physics, chemistry, or general science in high school. Tables are given to show the different relationships. E. L. M.

John J. Abel, Willard Gibbs Medallist. LESLIE HELLERMAN. *Chem. Bull.*, **14**, 135 (1927).—John J. Abel, distinguished pharmacologist and biochemist of Johns Hopkins Medical School, received the Willard Gibbs medal, May 27, 1927. The award was presented by Professor Stieglitz at the May meeting of the Chicago Section. It was made in recognition of his important contributions to chemical and chemo-medical science.

Doctor John J. Abel's productive research career began in 1890–91 with the publication of papers on cholesterin, biuret derivatives, and related topics. International notice came with the announcement of the isolation of a derivative of epenephrin (often called adrenalin) and the isolation in crystalline form of insulin. A brief resumé of his career as a student, teacher, and research chemist and the physiological actions of the "active principles" he has worked with is given. In conclusion, the author writes: "Dr. Abel enjoys the reputation of being thoroughly scientific in everything he undertakes; absolutely courageous in his stand for his ideals; fearless in the defense of his convictions. His influence on his students is great: he is upright and frank; severe, yet kindly." E. L. M.

The Chemist's Faith in the Invisible. B. CLIFFORD HENDRICKS. *Nebraska Educ. J.*, **7**, 246 (1927).—Dr. Hendricks has shown how the chemist makes most of his discoveries by a splendid exhibition of a most practical faith, even though a scientist is not usually associated with such ideas as faith. The chemist's faith centers about four kinds of invisible material: colloids, molecules, atoms, electrons. Their existence and qualities are to him truths. Even though he has never seen them, he stakes his reputation as a scientist upon their existence and the dependableness of their behavior. The writer illustrates the existence of colloidal particles by the separation of fat droplets from fresh milk as it stands. An emulsion of oil and water is given as another illustration of how these small colloidal particles can be separated—a process developed by Dr. Cottrell which is of much importance in the oil industry.

The author goes on to show why the chemist believes in molecules and atoms and electrons, and how by such a belief he has been able to give the world better equipment, larger production and relieved it of human suffering by the building of molecules of medicinals from different atoms which are in turn composed of electrons. E. L. M.

The Passing of Wonder. EDITORIAL. *School*, **38**, 562 (1927).—William Heard Kelpatrick states a new credo of man: his faith in tested thought. No longer does man fear the unseen world about him. He now realizes that he is in a universe controlled by laws that he can discover and use. He fears such things as cancer which he does not yet know how to control. His new faith gives him hope, however, of even controlling cancer.

More and more, man looks out with changed eyes upon a new world both seen and unseen. But many feel that in putting too much faith in his intellect, man has permitted science to render him near-sighted. He has abandoned, all too willingly, the unanswerable questions of man's purpose in the universe. With science has grown up a new attitude of security which is really false. Man has all too often forgotten that science has shown ability to answer only three questions for us: What? When? How?—that it has so far shown no power to tackle the greatest question of all: Why?

Along with the science and the faith in tested thought we must teach our children a new sense of wonder. With an appreciation of their own importance must be cultivated a sense of wonder at their own capabilities and chances for progress spiritually.

B. C. H.

Science at Its Best. EDITORIAL. *Colliers*, **79**, 54 (May 14, 1927).—The human race was shown at its very best a few weeks ago when television between Washington and New York was achieved. The interesting thing is how we got it—which is a story of the joint accomplishment of science and business. It is the product of the finest kind of technical skill and the most generous public spirit—of research at its best.

A few years ago chemists discovered neon which was regarded as of no practical use but just the reward of research. Yet that same rare gas supplies the neon lamps which make television possible and which incidentally are useful in directing airplanes and in many other routine industries.

The scientists who have done this, their predecessors and their associates, have created our modern world.

For all that, we have learned only partly how to use science, the great tool of progress and of civilization.

"Honor and support the imagination and the research which make television practicable. The spirit behind such achievement is as good as human nature affords."

J. W. H.

Professional Enthusiasm. C. E. BAER. *High-School Teacher*, **3**, 130 (1927).—Increased enrolment in teachers' organizations in the past eight years evidences a striking awakening of professional enthusiasm among teachers. This interest is found not only in general but in special groups, as science teachers' associations, Division of Chemical Education of the A. C. S., etc. Magazines have also been put forward to carry this professional enthusiasm to the desk of the teacher.

Science teachers have not carried this enthusiasm quite to its ultimate limit. They could make more of state and district meetings of teachers. There is much to be done. Many of our educational problems are just in the experimental stage. We need opportunity and incentive to get together and talk them over. Science organizations need to assume this leadership.

B. C. H.

Moseley. The Numbering of the Elements. GEORGE SARTON. *Isis*, **9**, 96–111 (1927).—An account of the life and work of Henry Gwyn Jeffreys Moseley (born November 23, 1887, killed at Suvla Bay by an enemy bullet August 10, 1915) with bibliography of his writings and a reproduction of the only existing good portrait.

Moseley's law, wrote Charles Urbain, "substituted a perfectly scientific precision for the somewhat romantic classification of Mendeléeff. It was something definite in the period of hesitating researches on the chemical elements. It terminated one of the most beautiful chapters in the history of science." The law confirmed in a few days the results of twenty years of work by Urbain on the elements of the rare earth group.

"Moseley's life work was done in four years. His career was like the meteor of a summer night. Thus he did not belong to any academy, because he was already gone before they knew of his existence or had time to consider his election. His apprenticeship as an experimenter had lasted only a year and then he had plunged at once very deeply into original research. His success was due to the combination of rare intelligence, excellent mathematical training, experimental skill, and last but not least (for there can be no genius without that) enormous endurance." TENNEY L. DAVIS

Samuel Guthrie (1782–1848). VICTOR ROBINSON. *Medical Life*, **34**, 103–52 (1927).—An entertaining article on "one of the most interesting characters in the early annals of American science, the backwoods chemist who gave to mankind the boon of chloroform," with portraits of certain members of his family (none of the chemist himself is known), pictures of his birthplace at Brimfield, Massachusetts, and his home at Sackett's Harbor, New York, etc., and with a reprint of his complete writings from the *American Journal of Science and Arts* for 1831–1832.

Guthrie discovered chloroform independently of Soubeiran and of Liebig, and apparently earlier than either. He prepared it by distilling alcohol with chlorinated lime, isolated it in a state of purity, and described its properties. He also worked with

potassium chlorate, mercury and other fulminates, gunpowder and primer compositions, with molasses from potatoes, and, on the purification of oil, turpentine. He made the important observation that mercury fulminate serves better for the igniting of gunpowder if it has previously been mixed with a third of its weight of oxide of tin.

TENNEY L. DAVIS

Notion of Intelligibility in Scientific Thought. A. E. HEATH. *Monist*, **37**, 199–201 (April, 1927).—A paper read at the Sixth International Congress of Philosophy in Cambridge, Massachusetts, September, 1926.

There is a change of attitude in recent discussions on the meaning of scientific thought, the inquiry now being into the broad structure of scientific thought as a whole, viewed as a background to the life of man. Modern physics turns more to abstract and comprehensive theories rather than to particular conceptions. The underlying conviction of all scientific labor is that in nature there is an inter-relatedness of all the parts and that science is competent to reveal this system. This conviction is the motive power of research. E. S. R.

Education Today and Yesterday—Back to School after Twenty-Five Years. W. M. KARSHNER. *Washington Educ. J.*, **6**, 169–70 (Feb., 1927).—The author advises every old graduate to follow his example, namely, to get out of the old rut and become a school boy again; to match up with the vigorous young minds of the youth of today—to work not according to inclination but as one of a group. Dr. Karshner finds great progress in bacteriology and chemistry in the past twenty-five years, and what is comforting to anyone interested in education, he also finds advance in the mental and moral attitude of the students. Far from crying that things were better in his own day, he finds improvement in every way. E. S. R.

The Vapor Pressures of the Alkali Metals. H. ROWE. *Phil. Mag.*, **3**, 534–46 (1927).—New methods of producing high vacua have made it possible in the last few years to attain pressures previously unattainable and apparatus has been devised by which these pressures can be measured accurately. Very few measurements have been made of the vapor pressures of the alkali metals and these usually at high temperatures. Here data from experimental work have been compared with pressures extrapolated from various formulas. No single formula represents the variation of pressure with temperature for any given metal, but from a comparison of all the results it is possible to get an approximate valuation of the pressures at various temperatures. E. S. R.

Peasantry or Power. MACY CAMPBELL. *J. Natl. Educ. Assoc.*, **16**, 73–6 (March, 1927).—Here are stated two aspects of the agricultural problem, a problem more far-reaching than that of slavery, for it is a problem of economic freedom for thirty million people. First, those who till the soil are gradually losing ownership of the land. The proportion of landless farmers is gradually increasing. As a consequence of this, the more capable young people will not stay on the farm and the land loses its best brains, only the "small potatoes are left." The percentage of feeble-minded in rural districts is higher. Brains from the farm are not running big business organizations where money is to be made. The remedy, says Mr. Campbell, is intelligent organization—coöperation on an immense scale, with the best brains of the farm leading the advance. This is to be done by the enlightenment of the young on the advantages of team work and training in group action. In the end all go up and down with the farmer. E. S. R.

In Self Defense. BARNET RUDMAN. *Educ.*, **47**, 468–71 (Apr., 1927).—A clever and convincing protest against the undercurrent of popular opinion which occasionally finds expression in such a phrase as, "Let us have an expert not a schoolteacher." The article indicates the line of the teaching profession, its adventure, its ultimate usefulness and possibility of spiritual wealth, and its demand for personality and courage in the face of public opinion. E. S. R.

Thermit and Icebergs. H. T. BARNES. *J. Frank. Inst.*, **203**, 611–34 (May, 1927).—Researches of thirty years ago showed B. that the equilibrium between the solid and liquid phases of water is most delicately balanced, and that when there is a temperature change of a minute fraction of a degree, one phase passes over into the other. The true freezing-point of water has to be defined as that of an intimate mixture of ice and water neither gaining nor losing heat. Practical application of the small temperature effect has been made use of to prevent the accumulation of ice, this requiring vastly less actual heat than getting rid of ice after it has been formed. Nature points the way to the powerful influence of the sun as a fighting tool.

In selecting a radiant beam for ice control, the selective absorption of water for heat rays must be carefully considered. In 1924 B. made studies with icebergs off Newfoundland; later with ice packs in the St. Lawrence River. A material known to the trade

for twenty-five years as thermit, an exothermic mixture of aluminum metal and iron oxide, was used in all the experiments. A temperature varying from 2500°C. to 3500°C. is produced in a few seconds. The actual number of heat units per pound of material is only 1500, much less than for coal.

As soon as the molten iron comes in direct contact with the ice or water a second reaction takes place which decomposes the water into oxygen and hydrogen. There is such a rapid evolution of gas that a slow explosion takes place. The thermit furnishes heat and explosion. The important fact is the output of energy in the penetrating heat rays which overcomes the exceedingly small temperature effects in the water. An iceberg gives the best example of the effect of strain induced by the thermit, as it is by far the largest mass of solid hard ice that could be experimented with. Every unit put into an ice pack acts as a point of infection which spreads over a greater and greater area until the whole mass is disintegrated.

Successful operations were concluded at Waddington, Ogdensburg, Clark Island, Oil City and Franklin, Newfoundland, Notre Dame Bay, Jenkin's Cove, North Island, in removing ice packs and icebergs. There is no better place for experimenting than Notre Dame Bay. To cite one experiment, two charges of 60 lbs. and 100 lbs. each were exploded in a huge iceberg. This was at six in the evening and no ice was knocked off by the explosion. The berg had disappeared by morning.

Experiments with high explosives confirm the results obtained by the U. S. Coast Guard that they have little or no effect on these solid masses of ice. The action of the heat of thermit is different since it sets up the thermal expansion strain which causes innumerable cracks and fissures through which the sun and melted ice water gain access, causing the falling apart of the ice wherever the heat has been applied. Eighteen photographs accompany the article. J. H. G.

The Discrimination of the Quality of Brick by Means of Sound. J. OBATA. *J. Frank. Inst.*, **203,** 647–59 (May, 1927).—The sound produced by striking material has often been utilized to ascertain its quality. With brick it is generally believed that one which gives a metallic sound when struck by a hammer has superior quality as an architectural material, and this opinion is undoubtedly correct. Obata made experiments upon about thirty specimens of brick. He employed a condenser microphone, the record being obtained with an oscillograph made by the Cambridge Instrument Company, England. In discriminating a large number of bricks in practical work, a standard instrument of sound is in all cases necessary. The tuning fork is not suitable. The tone of a xylophone is most suitable. Tones of a Galton whistle were also recorded. Further investigations are to be made. Article fully illustrated. J. H. G.

The Glow Test for Metals of the Platinum Group. C. W. DAVIS. *J. Frank. Inst.*, **203,** 679–99 (May, 1927).—The method of Curtman and Rothberg is quoted. The tests of Gruetter, upon acid solutions of copper concentrates which gave a positive reaction for platinum group metals, are duplicated by the author. The author then makes further study of the problem along the lines of contact catalysis with special reference to the glow reaction; the effect of different factors (developed in the theory) on the glow reaction; and the conditions that should be maintained to give reliable results when the glow reaction is used as a test for the platinum group metals. The method of Curtman and Rothberg as quoted is, "The substance to be tested is brought into solution by any of the common methods and about 0.2 cc. of this solution is absorbed in a piece of thin asbestos paper by alternately dipping the paper into the solution and heating until the required volume has been absorbed. The moist paper held by one end in a pair of tongs is now heated to redness in the Bunsen flame, then removed, and after the redness has ceased, but while the paper is still hot, it is brought into a stream of a mixture of illuminating gas and air from a Bunsen burner. If platinum is present, the asbestos paper will begin to glow." J. H. G.

The Science Demonstration in Junior-Senior High School. E. S. OBOURN. *Gen. Sci. Quart.*, **11,** 227–36 (May, 1927).—The practice of the John Burroughs School, St. Louis, Mo. J. H. G.

A Study of the Offerings of General Science Texts. W. J. KLOPP. *Gen. Sci. Quart.*, **11,** 236–46 (May, 1927).—Nine texts are carefully studied. Objectives of general science teaching not properly realized in texts. Authors do agree upon major objectives to be realized. The great majority of teachers use one text. Eighty per cent of teachers agree as to the effective value of extra reading assignments, but they are uncertain as to how much reading is actually done. The selection of extra reading material is not made on the basis of pupil needs and interests. Too much stress is laid upon the particular material of special interest to the teacher. Supplementary

work will be poorly selected, demonstrations rarely given, and field trips not attempted unless the teacher is well prepared in the field of science. Interest and ardor of many children will be sacrificed by the limited courses of study offered by many modern texts. Children using different texts in different schools cannot compete on the same basis. J. H. G.

The Present Status of the Controversy, Demonstration versus Laboratory Method. F. A. REIDEL. *Gen. Sci. Quart.*, **11**, 246–54 (May, 1927).—There are twenty-two general conclusions pro and con. "The above conclusions of the workers in this research into the comparative effectiveness of the two methods are offered for two reasons; they show the present lack of a basis for deciding as to whether one method as a whole is better than another method as a whole; and, secondly, the need for a wide-spread general investigation of this matter by science teachers in all the sciences." The investigations are not beyond the scope of the class-room teacher. J. H. G.

The Science of Common Things. J. R. LUNT. *Gen. Sci. Quart.*, **11**, 263–80 (May, 1927).—A continuation of radio science lessons broadcast from Station WEEI. V. "Ye Old Tinder Box." "The History of Fire." VI. "How to Make Water Boil on Ice." VII. "Jack Frost and His Funny Tricks." VIII. "A Candle and How It Burns." J. G. H.

Internal Stresses in Solids. ANON. *Gen. Sci. Quart.*, **11**, 284–6 (May, 1927).—Quoted from "Travelers Standard." Solids such as glass and enamel, which do not "yield" sensibly before rupture when they are exposed to tension, compression or torsion, are especially likely to be under a condition of great internal stress, unless they are carefully annealed after having been strongly heated in the course of manufacture. Fragments of a bursted ink-well and Prince Rupert drops are photographed. J. H. G.

Leadership in Educational Research. B. R. BUCKINGHAM. *J. Educ. Res.*, **15**, 239–45 (April, 1927).—The author recognizes as a leader in educational research one who combines conspicuously two characteristics: that of intellectual leadership, which depends upon mental powers, knowledge, skill, and character; and human leadership which includes ability to get on with one's fellows and the ability to get people to work together. In both types of leadership there is an essential creative capacity. The leader must be able to visualize new situations, to forecast results by combining and applying known elements. Not routine operations but new conceptions mark the leader.

Since 1890 elementary-school attendance has increased twice as fast as the population of the country, and high-school attendance has increased thirty-one times as fast. A vast number of problems related to the training of children of varied intellectual levels have arisen which require the attention of trained workers for their solution.

The present methods of studying the curriculm, the detailed treatment of textbook materials, the diagnosis of the intricacies of individual differences among pupils, the application of objective measurement, all are characteristic of contemporary thinking in education, and are the author's reasons for saying we are in need of quantity production in research.

We see that a tremendous number of problems cry aloud for solution. It is the task of leaders in research to state these problems, to formulate methods of attacking them, and to organize, train, and inspire those attempting to solve them.

To the author it seems that research should go hand in hand with teaching throughout the entire range of educational effort; and just as some university professors carry a reduced teaching program because of their fitness for research, so should some public-school teachers carry a lighter teaching load in order that they may contribute to verified educational data. The training of workers in research is appropriate not only in university circles but also in public schools; and there should be at the service of every school district a person who can direct such research.

The author lists the characteristics desirable in such a leader. (1) He should have had practical school experience. (2) He must possess a truly scientific method and be able to apply it to educational problems. (3) He should be able to analyze complex problems into their simpler elements and to organize an attack upon them in this divided form, and should likewise be able to coördinate the various parts of larger topics into an articulated whole so that coöperative research may be carried on. (4) He should be a scholar in his field. (5) He should have "extractive power" and be able to secure information. R. M. P.

Day Dreams: A Cause of Mind Wandering and Inferior Scholarship. GILBERT L. BROWN. *J. Educ. Res.*, **15**, 276–9 (April, 1927).—Inferior work done by students may be accounted for by lack of intelligence, laziness, working for room and board, lack of exercise, and mind wandering. The author investigates the problem of mind wandering in order to discover its prevalence and nature, and method of control..

The most frequent cause of mind wandering was found to be day dreaming. Day dreams are distinguished from desire, which is regarded as an impulse directed toward the attainment of an objective, and from planning, which takes into consideration the ability and resources of the person who is to act toward attaining an objective. In the day dream, although there is an object or situation around which the day dream centers, there is no action or impulse directed toward its attainment and, consequently no planning or method of approach involved. The day dreamer is satisfied with the pleasure which he derives from the dream and makes no attempt to realize the situation imaged in it.

Two characteristics which make day dreams hard to control are, first, that they are delightfully pleasant with the dreamer receiving the plaudits of admirers, and, secondly, they are so fatally easy, affording a high degree of pleasure with a minimum of effort.

The subject-matter of day dreams may be classified into three kinds, namely; love affairs, athletic activities, and professional accomplishments.

Day dreams interfere with study in that they occupy the time which should be devoted to serious work, and in that they leave the mind unfit for serious study. A person accustomed to doing only easy, pleasant things is likely to find anything disagreeable which requires effort and, accordingly, to lack interest in it. There results a mental flabbiness which is a positive hindrance to scholarship.

Control of day dreaming seems to be a difficult problem. Perhaps the most effective method is to explain to students the nature of day dreaming and its bad effects. Another method of control is to discourage the reading of so much popular literature which is itself largely an expression of day dreams and which stimulates the reader to more day dreaming. Teachers may aid pupils in concentration by assigning all the work which the students may reasonably be expected to do and by requiring that it be prepared satisfactorily. The pressure of necessity will aid in keeping the mind upon the work.

R. M. P.

Relation of Subjects Taken in High School to Success in College. L. BOLENBAUGH AND W. M. PROCTOR. *J. Educ. Res.*, **15**, 87–92 (Feb., 1927).—The student who has followed a vocational pattern in his high-school work is practically barred from most colleges. It is possible that we are thus eliminating many students who, if given a chance, might attain distinction in college.

Stanford University has followed a very liberal policy in admitting students, admission being based on fifteen units of high-school work, of a grade of B or better, and the only specific requirement being two units of English.

In this study an effort was made to determine whether those who entered Stanford with an academic pattern of high-school work achieved higher standing in college subjects than those who entered with a vocational pattern. The entering classes of 1921 and 1922 were given Thorndike examinations at the time of admission and were followed through their entire college course. Each student's high-school record was converted into the point system, and each student was classified as one who had an academic or a vocational pattern of preparatory work. Four hundred ninety-four students were placed in the academic group and 111 in the vocational group.

The comparative college records of the two groups are given in the first table, while in the second table are given the comparative scholarship ratings, and intelligence scores. In a third table are found correlations between the Thorndike score and high-school scholarship, and between the Thorndike score and college scholarship. A comparison of the two groups shows the results surprisingly in favor of the vocationally trained group. The authors find it rather disconcerting to have so rudely shaken the tradition that an academic pattern of high-school work is a better index of college success than a vocational pattern.

They conclude: (1) Not enough difference exists between the two groups to justify any discrimination against an applicant for college admission because he took from fifteen to fifty per cent of his preparatory subjects in the vocational group of high-school subjects. (2) There are some indications that the vocational type of students tends to be more consistent in scholarship. (3) When the high-school records and intelligence tests are combined in a regression equation the resulting correlation indicates that the vocational pattern student is as good a college risk as the academic pattern student. (4) College preparatory courses in high school can permit the election of from three to five vocational subjects without weakening the student's chance of college success. (5) Colleges can well afford to give the high schools more freedom in the matter of courses taken by prospective college students. A good high-school record, regardless of the pattern of subjects taken, when combined with an intelligence test, is

a better basis for selecting candidates for college admission than either the high-school record or the intelligence test alone. R. M. P.

College Records and Success in Life. HUGH A. SMITH. *Educ.*, **47**, 513–29 (May, 1927).—Notwithstanding the fact that youth is obsessed with the desire for college degrees, the public does not regard high scholastic attainment as a measure of future success in life.

Smith discusses the results of a two-years' study of this paradox. For the work there were available, from one of our large universities, the class records of all the graduates of the bachelor's course for a period of forty-five years—the most recent data being fifteen years old. The records of somewhat over eighteen hundred persons were included.

Success was judged by: (1) Fairly complete alumni records. (2) The frank opinions of numerous graduates. (3) The "Who's Who" test.

It was strikingly shown that between college careers and success in life there exists a corresponding relation; indeed, if a student belongs to the highest tenth of his class his chances for achieving a career in life distinguished by the approval of his fellowmen are forty times as great as they are if he belongs to the lower nine-tenths; and further, the probability of his name being found in lists like "Who's Who" will be fifty times as great.

The reliability of high scholastic standing as an index of future success results from the fact that the student is under the critical observation of his instructors two thousand times during his four years.

Smith shows that there is no authentic evidence that a college record will become, in the future, a less certain barometer of success.

Smith suggests that the popular paradoxical opinion on the subject is a heritage from the pioneer days. O. J. S.

The Atomic Weight of Silver. B. BRAUNER. *Nature*, **119**, 527 (Apr. 9, 1927).—An elucidation of the author's critical note concerning the work of Baker and Riley. The principal theoretical argument is based on the interdependence of the atomic weights of the elements silver, nitrogen, and chlorine. Accepting 107.864 would make nitrogen 13.999 which Brauner finds exceedingly improbable especially since Baxter reports [*Proc. Am. Acad.*, **12**, 699 (Dec., 1926)] N = 14.006(7) which would agree with the higher value for silver. Secondly, when silver once passes into the vapor state it is not easily condensed but forms a colloidal dispersion as a fog and may in this condition pass out of the apparatus. H. K. M.

Lister's Contribution to Preventive Medicine. C. J. MARTIN. *Nature*, **119**, 529–31 (April 9, 1927). **Some Aspects of Lister's Scientific Work.** W. BULLOCH. *Nature*, **119**, 531–3 (1927).—The two papers give a concise review of Lister's life work. H. K. M.

The Coefficient of Ionization of a Fused Salt. T. M. LOWRY. *Nature*, **119**, 564 (April 16, 1927).—All the data required for a formal solution of the problem are available but the results indicate an ionization of about 200%. They represent an anomaly which merits consideration. It is plausible to attribute this effect to the presence of multiply charged ionic aggregates resembling the ionic micelle of a colloidal electrolyte since these would increase both the viscosity and the conductivity of the liquid. H. K. M.

The Lister Centenary Celebrations in London. ANON. *Nature*, **119**, 570–2 (April 16, 1927).—An account of the celebrations during the Lister Centenary week in London in which the speakers dealt with the various aspects of his life and work. H. K. M.

Advantages of the Ring Method for the Study of Surface Equilibria of Colloidal Solutions. P. L. DU NOUY. *Nature*, **119**, 598 (April 23, 1927).—The measurements are easy and simple to perform with good accuracy by means of the tensiometer and take but one-third the time of the drop method. This matter of time is extremely important in the field of colloid chemistry especially in such measurements as the decrease in surface tension as a function of time. H. K. M.

The Formation of Twin Metallic Crystals. G. D. PRESTON. *Nature*, **119**, 600 (April 23, 1927).—Tutton states that the twinning plane is usually one with low indices and indeed very often a primary face. To this geometrical law of twinning we may add the physical conditions (1) that the reflection plane can only be one such that the operation of twinning does not bring atom centers closer to one another than the closest distance of approach of atoms in either component of the twin and (2) that the components of the twin have in common at least one plane of atoms. The above hypothesis is applied with success. H. K. M.

Recent Books

The Evolution and Development of the Quantum Theory. N. M. BLIGH. Foreword by Professor Max Planck. Longmans, Green and Co., New York, 1926. 112 pp. 14 × 22 cm. $3.00.

This book attempts in a brief 96 pages to present the phases of the quantum theory which are indicated in the above title of the book. By reason of the space occupied the volume can only be the merest outline of one of the most revolutionary ideas in physics and chemistry during the present century. It is difficult, therefore, to see what purpose the author had in mind in writing the book. It is not sufficiently detailed to be of any great value to the student. It is entirely too scientific a treatment for the general reader. It does give an outline sketch of the important features of the original quantum theory and points out, in the concluding chapter, why this theory is inadequate and that the new quantum theory is in process of formulation. The old theory is introduced in this book, as it arose, from the standpoint of radiation. It is developed with respect to the light-quantum hypothesis, atomic heats, the Nernst heat theorem, and the quantum theory of optical spectra. To show the difficulties which the author is under in writing a book of this brevity it is only necessary to point out that the subject of quantum theory in photochemical reactions occupies two and one-half pages. So far as the reviewer is aware this could only serve to tell the student that the quantum theory bore some relation to photochemistry and that it would be necessary to buy another book to find out more concerning the subject. The reviewer suggests that the money that might be spent by the student in purchasing this book should be devoted to the purchase of Lewis' Volume III of the System of Physical Chemistry, published by the same publishers. He will obtain much more value for his money and something of real usefulness on his reference shelf.

HUGH S. TAYLOR

Katalyse mit kolloiden Metallen. WALTER HÜCKEL. Akademische Verlagsgesellschaft, Leipzig, 1927. viii + 86 pp. 10 figs. 14.5 × 21.5 cm. Paper, 5M.; bound, 6M.

This is Volume 6 of the series *Kolloidforschung in Einzeldarstellungen*, edited by R. Zsigmondy.

In a short introduction the author points out that catalysis in a heterogeneous system is governed not only by the rate of the chemical reaction which is taking place but also by the rate of diffusion of the reacting substances into and through the surface film and the rate of diffusion of the final product out through the surface film into the body of the liquid. He points out that the rate of diffusion is in many instances so much slower than the rate of chemical reaction that the rate of diffusion becomes the limiting factor, and that when protective colloids are used, they may very profoundly influence this rate of diffusion, or they may affect the nature of the surface of the catalyst.

Studies of catalysis by colloidal metals have been made involving the reaction, $H_2O_2 \longrightarrow H_2O + O_2$. Hydrogenation reactions have been extensively studied. Some studies have been made of catalytic oxidation but other types of reactions have not been studied to any extent.

In order that a colloidal metal may be used as a catalyst the sol must possess: (1) an appreciable concentration, (2) small particles (relatively great extent of surface), and (3) a protective colloid must be present to protect against coagu-

lation but the protective colloid must not "poison" the catalyst.

The main part of the book is devoted to a review of colloidal metal sols prepared by Paal's method (protalbinic or lysalbinic acids as protective colloids) or by Skita's method (gelatin or gum arabic as protective colloids). Complete directions are given for preparing Pt sols containing 50% Pt; Pd sols containing 47% Pd; and Ir sols containing 19% Ir. These sols can be evaporated to dryness, and heated at 105–110°C. and still be readily dispersed when water is again added. The properties of these sols are discussed in considerable detail.

Hydrogenation reactions are next taken up and the necessary apparatus is illustrated. Directions are given for the hydrogenation of acetylene to ethylene and ethane; of phenyl propiolic acid to cinnamic acid; of nitrobenzene to aniline; and of benzaldehyde cyanhydrin to benzyl alcohol.

Inorganic compounds can likewise be hydrogenated by these preparations. In the presence of protalbinic acid and a trace of colloidal palladium, $Cu(OH)_2$ is converted by H_2 into a colloidal copper sol. One milligram of colloidal Pd is sufficient to convert 0.2 gm. of $Cu(OH)_2$. Similarly sols of Ni and Co can be prepared. Ammonium bichromate solutions under similar treatment yield a sol of $Cr(OH)_3$; ammonium molybdate solutions yield a sol of $Mo(OH)_3$ and ammonium meta vanadate yields a sol of $V(OH)_3$.

Paal's colloidal metals can be used as catalysts to hydrogenate double and triple bonds in aliphatic organic compounds but are without effect upon the carbonyl group or upon the double bonds causing the aromatic character of benzene, naphthalene, pyridine, or quinoline. The Skita preparation, on the other hand, will hydrogenate not only the aliphatic double and triple bonds but also the carbonyl group and the aromatic carbocyclic and heterocyclic compounds, including even the very resistant (to other methods of hydrogenation) isoquinoline. A number of illustrations of methods are given.

Catalytic oxidations are discussed at some length but the chief illustrations are methyl alcohol + air + colloidal metal = HCHO; and $2CO + O_2 = 2CO_2$.

A discussion of the kinetics of colloidal catalysis is given but here the only reaction sufficiently well studied to be adequately discussed is $2H_2O_2 \longrightarrow 2H_2O + O_2$.

The question of poisoning of the catalyst is discussed at some length. Only the Paal preparations have been sufficiently well studied to generalize. Hg and HgO are fatal to hydrogenation reactions but not to the reaction $2H_2O_2 \longrightarrow 2H_2O + O_2$; here, however, $HgCl_2$ acts as a poison. As a rule oxides and hydroxides of other metals are less effective poisons than is Hg.

In the final section the author discusses the theories of catalytic hydrogenation. There is a good discussion of the various theories of hydrogen activation but the author does not draw any definite conclusion as to the theory which should be accepted.

The book closes with a subject and author index. In general, it may be regarded as treating a very limited portion of the general field of catalysis, with especial reference to the catalytic behavior of Pt, Ir, and Pd, and even here only those preparations prepared by Paal's or Skita's methods. However, it brings together a considerable amount of widely scattered literature and as such serves a useful purpose. It should be of interest to those who are studying catalytic reactions and also to the organic chemist who may wish to selectively hydrogenate some organic compound.

ROSS AIKEN GORTNER

Digest of Elementary Chemistry. MARTIN MENDEL, M.A. Globe Publishing Company, New York, 1927. v + 234 pp. 22 figures. 12 × 18 cm. $0.67.

The name indicates the purpose of the book, which is elaborated in the preface. "This book is designed to present in concise and logical form those essential facts of chemistry which are necessary not only

for the successful completion of the course as measured by examination results but also to supply that informational background which is conducive to good thinking."

Each chapter dealing with descriptive chemistry begins with a summary of the preparation, properties, and uses of the substances treated, together with equations and diagrams of apparatus for the most important experiments. Following these are sets of questions or problems, about 900 in all. A chapter devoted to Laws, Theories, and Hypotheses includes a four-page treatment of the electron theory and an excellent periodic table giving electron diagrams of the first 25 elements. There is a chapter on Chemical Tests and one on Definitions. Tables of essential properties and Regents examination papers for the last five years conclude the book.

The summaries of processes and properties are generally good, although the effort to condense, leads to statements in the theoretical portion that are not always clear. The questions are much broader than the summary text. The figures are clear and notably well labeled. All problems are grouped in one chapter with a very large proportion of them involving volume relations.

This digest is better done than most such books. It should be used for review purposes only. Most modern texts have summaries, and the use of a new set for review does little to form habits of independent study. Questions differently worded from those the pupil is accustomed to hear are valuable, and the scope and wording of those in this book are excellent. The implication in the preface that a digest might be substituted for a well organized textbook is unfortunate, as it involves the doubtful ethics of cramming a pupil to pass an examination in a subject that he has not mastered.

R. B. BROWNLEE

Chemical Calculations. ERNEST L. DINSMORE, A.B. Chairman of the Chemistry Department, Boys High School, Brooklyn, N. Y. The Globe Book Company, New York City, 1927. First edition. vi + 182 pp. 7 figures. 12.5 × 19 cm. $1.20.

As the title indicates, this is a book written to strengthen the student in the calculations encountered in first-year chemistry. The author believes that while the lamentable weakness of the average "beginning" student is due in part to failure to grasp the reasoning process involved, a larger factor is the lack of properly graded problems in the average textbook. "The aim of the book is to provide a wealth of material in chemical calculations by means of which the course may be vitalized and strengthened in those parts which are so often considered difficult and uninteresting."

The book includes 14 chapters and an appendix consisting of 8 tables of data needed for solution of the problems. The title does not fully cover the scope of the book. Chapters I, "Matter, Changes, and Atomic Structure;" II, "Symbols, Formulas, and Molecular Weights," and VI, "Chemical Equations," are purely theoretical and duplicate material to be found in any good textbook. They are simply and clearly written, however, and the duplication is no doubt justified in view of the importance of the material treated.

Most of the chapters present briefly and clearly the theory underlying the type of calculation considered, then solutions of several typical problems, then a well-chosen group of problems for the student to solve. Chapter XII includes 272 problems, grouped under the chapter headings of the average textbook, which makes them admirably adapted for outside assignment as the course progresses. Chapters XIII and XIV consist of 54 selected problems from those set by the State of New York and by the College Entrance Examination Board. A total of 148 study questions and 625 problems are included in the book. No answers are given.

Teachers of college courses will be quick to note several serious omissions, among

which may be mentioned electrochemical calculations, Faraday's law, and calculations based upon oxidation-reduction reactions. The little book is clearly and simply written and well arranged and provides very helpful material on the topics treated.

A. P. BLACK

Principles of Chemistry. JOSEPH H. ROE, Ph.D. Professor of Chemistry, George Washington University Medical School. Lecturer in Chemistry, Central School of Nursing, Washington, D. C. Captain, U. S. Medical Reserves. The C. V. Mosby Company, St. Louis, Mo. First edition, 1927. xv + 378 pp. 13 × 19.5 cm. $2.50.

It is the purpose of this text to serve as a comprehensive guide for lecture and laboratory work in the training of students of nursing and of home economics. The author has covered the principles of chemistry as they appear in the standard college textbooks. However, his treatment of such subjects as atomic structure, periodicity, and isotopes is very brief, the special emphasis being placed upon the application of the science of chemistry to nursing, pharmacy, and medicine. All of the common non-metallic elements are discussed in the usual manner including a comprehensive chapter on acids, bases, and salts, and the theory of ionization. The metallic elements which are important on account of their medicinal activity are likewise included in the text. The chapter on organic chemistry gives a brief outline of the divisions of organic chemistry and the structures of the compounds important to nursing are included. The discussion of proteins, fats, and carbohydrates is very complete, followed by a rather elaborate consideration of the subjects of metabolism, digestion, and dietary requirements. The experiments included in the text have been especially well selected with the aim of familiarizing the nurse with chemistry as it appears in the home. It is of special interest to note that exercises in urine analysis have been included.

In the mind of the reviewer the text is admirably suited for the teaching of chemistry to nurses.

JOHN C. KRANTZ, JR.

Organic Chemistry. FRANK E. RICE, Professor of Chemistry, North Carolina State College. McGraw-Hill Book Co., New York City. First edition, 1927. ix + 303 pp. 14 × 20.3 cm. $2.50.

This book was especially designed for students in applied biological fields: agriculture, home economics, medicine, dental science, pharmacy, and veterinary medicine. The author states that he also had in mind those people who are not on the campus but wish to add to their knowledge of the relation of chemistry to modern life.

It has many features which distinguish it from most other texts written for this class of students. It is not merely an abridged edition of a text originally written for chemistry majors, as is so often the case. The material is presented in a somewhat different sequence than that usually followed. The student is introduced to a number of important principles as well as several classes of compounds in the early chapters on Methane and Derivatives and Ethane and Derivatives. Emphasis is given to the descriptive material by placing it first and giving it the major space in each chapter. Only those methods of preparation and reactions which are of a general character are presented. The author has also dropped the time-honored custom of designating these reactions by the names of their originators.

Theoretical discussions are limited chiefly to the chapters on Valence and Molecular Structure and Optical Activity. Such topics as mechanism of reaction, proof of structure and scientific nomenclature have been omitted.

At the end of each chapter is found an excellent selection of "Experiments Recommended for Laboratory or Classroom Demonstration" and "Suggested Topics for Further Study."

The author has discussed every class of organic compounds of importance to those in the professions that deal with animal and plant life.

While this book was not designed for chemistry majors and is not entirely suited to their needs, they would find it very profitable reading.

J. W. HOWARD

The Development and Present Position of Chemical Analysis by Emission Spectra. F. TWYMAN, F.R.S., F. Inst. P. Adam Hilger, Ltd., 24 Rochester Place, London, N. W. 1, England, 1927. vii + 35 pp. 20 figs. 15.5 × 24 cm. 2s. 8d., postpaid.

This booklet is one of a series of publications the purpose of which, as frankly stated in the preface, is "to encourage and facilitate the use of the spectroscopes and spectrographs made by Adam Hilger, Ltd." While this booklet is the fifth of the series in the order of publication, its logical position would place it first since it deals with the history and development of spectrum analysis.

The material presented in this most recent contribution from the Hilger laboratories is prepared for the use of teachers of chemistry and others who may be interested in the development of spectrum analysis. It is arranged in the form of two lectures by F. Twyman, Managing Director. Lecture I is devoted to the discovery and development of spectrum analysis, taking up in turn the early history, the period of suspended development, the revival of spectrum analysis, and the development of modern apparatus. Lecture II discusses the methods of producing, observing, and photographing spectra, the measurement of wave-lengths, identification of metals by their emission spectra, and the applications of spectrum analysis to problems of a purely theoretical nature as well as to the practical analytical problems of the industrial laboratory. While this publication makes no pretense to being a booklet of instruction, it nevertheless contains many suggestions which will be very welcome to the beginner in the field of spectrum analysis.

The illustrations are useful in explaining the descriptive matter, and these are available in form of lantern slides for class room or lecture purposes, a set of 20 being offered for sale at 35s. plus postage.

Because of the rapidly growing interest in the applications of spectrum analysis to a wide variety of modern problems, this booklet will form a valuable addition to the most excellent series of publications which are already so well known to workers in this field as clear, accurate, dependable, and useful handbooks in a subject which presents so many possibilities for future development.

B. S. HOPKINS

Geraniol to Be Tried on European Earwig. Will geraniol, so charming to the Japanese beetle, prove an equal lure to the sensitive "smellers" of the European earwig? This is what entomologists in the states of Washington, Oregon, and Rhode Island, where the European earwig is making inroads upon garden vegetables, hope to find. Tests are about to be made to attract the European earwig by this pungent odor as Japanese beetles have been drawn. Woe to them if they respond, for methods will immediately be devised for a quick massacre once they show their willingness to swarm about the odor.

Users of perfumes must admit the good taste of the Japanese beetle, since geraniol, made from geranium oil, citronella and rose oils, has long been used in perfumery. The beetles like a somewhat small dose. When it is too concentrated it tends to repel them. Five per cent geraniol used in combination with bran-molasses bait carriers has been most effective in attracting the Japanese beetles.—*Science Service*

A FEW MOMENTS WITH THE BUSINESS MANAGER

SURE WE WILL!

Just the other day we were talking with some of our readers who will attend summer school. During the conversation it was proposed that while at summer school, it would help boost the Journal of Chemical Education if each one would make it a point to tell their new acquaintances about the magazine. They replied in unison, "Sure we will."

If all of us who are at summer school just take advantage of every occasion which presents itself to casually mention how helpful and valuable the Journal of Chemical Education is, this will result in a large number of new subscribers. Our growth so far is largely the result of this sort of coöperation. Let us work together for the continued growth and betterment of the Journal of Chemical Education. Let our answer be, "Sure we will."

YOUR FAVORITE MAGAZINES

A real opportunity will be presented to our readers in the very near future. Most of us read several magazines regularly. With this thought in mind, we are making arrangements with many of the well-known national magazines so that we may be able to secure them and the JOURNAL OF CHEMICAL EDUCATION at very attractive clubbing rates.

On this page next month we shall announce some of the clubbing rates for various national magazines which are coöperating with us. We believe our readers will greatly appreciate this service. The measure of this appreciation will be the number of subscriptions which we shall receive. That we may continue to merit the granting of this arrangement to our readers from year to year, we sincerely hope all of us will make the most of it.

Watch this space for the special clubbing combinations of magazines. You will help the JOURNAL OF CHEMICAL EDUCATION by subscribing for your magazines through its office.